OUR BODIES AND HOW WE LIVE

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OUR BODIES AND HOW WE LIVE

AN ELEMENTARY TEXT-BOOK OF PHYSIOLOGY AND HYGIENE FOR USE IN SCHOOLS

BY

ALBERT F. BLAISDELL, M.D.

AUTHOR OF "CHILD'S BOOK OF HEALTH," "HOW TO KEEP WELL," "LIFE AND HEALTH," "PRACTICAL PHYSIOLOGY," ETC., ETC.

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PREFACE TO REVISED EDITION

It is now twenty years since this book was first published and ten years since it was revised and reprinted. Meanwhile many important discoveries have been made concerning the nature and propagation of bacteria, and many changes have taken place in the attitude of scientific men towards the causes and restrictions of contagious diseases and the promotion of personal and public health.

The author has taken advantage of the demand for another revision to rewrite, rearrange, and illustrate this book in accord with the latest teachings in this branch of science.

In this edition, as in previous editions, it has been the aim of the author to prepare a text-book for elementary schools which should set forth clearly and tersely the more important and interesting facts about our bodily life.

It is believed that boys and girls in elementary schools should have an opportunity to learn a few essential things about the anatomy and physiology of their own bodies. These facts in themselves are of comparatively little worth unless they become the means of enabling our young folks to understand thoroughly the simple laws of health and to apply them intelligently to their daily living. With this in mind, the author has aimed to lay marked emphasis

in each chapter on such points as bear directly upon personal health.

In this book, as in the other books of this series of school physiologies, there has been added to the text a number of carefully graded and practical experiments sufficiently varied to allow a wide range of choice. For the most part they are simple and can be performed with apparatus that is inexpensive and easily obtained.

This book complies fully with the laws of those states which require in their public schools the study of the nature and effect of alcohol, tobacco, and other narcotics upon the human system.

The author would acknowledge his indebtedness to Dr. Margaret B. Wilson of the New York Normal College for careful criticism of his manuscript and for valuable assistance and suggestions in reading the proofs, and also to Professor H. W. Conn of Wesleyan University for the use of a number of illustrations from his work on bacteria, recently issued by the publishers of this book.

A. F. BLAISDELL

WINCHESTER, MASS.
March, 1904

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EXPLANATION OF THE FRONTISPIECE

A Study in the Anatomy of the Human Body

(Intended for Reference and Review Exercises.)

Presenting Important Muscles, Arteries, Veins, Nerves, and also a Few Organs of the Chest and Abdomen. (Front view.)

The frontispiece is a representation of the human body. The skin has been removed. The bones and muscles that make up the front wall of the chest and the muscles and fatty tissue that compose the front of the abdomen have also been removed.

On the left side of the figure (except chest and abdomen) only the skin and fascia have been removed, showing the large veins of the head and neck and also the principal superficial veins and nerves of the upper and lower limbs. The outline of the tibia is also shown.

On the right side of the figure (except chest and abdomen) a few large muscles have been removed from the limbs, exposing other large muscles and also important arteries, veins, and nerves. The arrangement of the fascia about both knees is also shown.

1. The **muscles** and **tendons** shown in the figure should be studied in connection with the text of Chapter III. Compare muscles and tendons of figure with those shown in Figs. 38, p. 49; 39, p. 50; 40, p. 51; and 42, p. 52. Note the display of tendons on right forearm, the palm of right hand, the front of right leg, and the top of right foot.

2. The **arteries**, represented in the figure, should be compared with those in Figs. 83, p. 135; 84, p. 137; 85, p. 139; 91, p. 147; 92, p. 149; 97, p. 156; and 99, p. 158.

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5. The **heart** and **lungs** and their **great vessels**, as shown in the **thoracic cavity**, should be studied in connection with Chapters VII and VIII. Compare with Figs. 83, p. 135; 84, p. 137; 85, p. 139; 89, p. 145; 92, p. 149; 100, p. 162; and 102, p. 164.

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A STUDY IN THE ANATOMY OF THE HUMAN BODY

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OUR BODIES

AND HOW WE LIVE

CHAPTER I

INTRODUCTION

1. The Study of Physiology in Schools. We are now to begin the study of a few things about our bodies and how we live. This branch of our school work, which is commonly called **physiology**, appeals to every thoughtful young person.

The reason for it is plain enough, for it is the study of ourselves. It describes the several parts of our bodies and tells us how they do their work; it aims to make clear a few of the great laws of health, and teaches us why and how we should obey them.

With this knowledge we may hope to live happier and more useful, because healthier, lives.

2. The Importance of the Study. What study could be more important, more interesting, and more fascinating than that which has to do with the structure and welfare of our own bodies!

We gaze with wonder and admiration at the marvelous work done by the intricate machines made by man. Well

we may, for they seem endowed with life. But in the human body we find not simply a most perfect and delicate machine, but one endowed with life, a mind, a soul.

Indeed, the longer we live, the more we study and reflect, the more we shall realize the great fact that the all-wise Creator, in his goodness and wisdom, has provided us with bodies which, in the words of the Psalmist, are "fearfully and wonderfully made."

3. Questions often asked by Thoughtful Persons. We must indeed be very dull if we have not at some time or other in our lives asked ourselves many curious questions about "the house in which we live."

Why are we warm? How are we able to move our limbs? How often does the heart beat? Why do we feel warmer after running or exercising with dumb-bells?

By what strange magic are the milk, beefsteak, and eggs we eat changed into bone, teeth, and muscle? Why does the doctor feel our pulse and put a thermometer under our tongue when we are ill? Why is it so hard to see for a few moments after coming into a darkened room from the sunlight?

These and hundreds of other questions, both curious and important, can be answered by those who have mastered the simple principles of the subject as told you in this book.

4. Animals are in Motion. We need not be told that some part of our bodies, as the heart, is always in motion. Even in sleep, when the eyes, the hands, and the feet may be still, the rise and fall of the chest in breathing and the beating of the heart never stop.

We also know that we can move from one place to another. We need not wait, like the trees in the woods,

for the wind to blow us to and fro, or, like the pebbles by the roadside, for somebody to move us. When we choose, we can move from place to place.

Indeed, it is true that every living animal, even the tiniest creature that lives its brief life in a single day and can be seen only with the help of the microscope, has the power to move of itself.

5. Animals are Warm. Even in the coldest day of mid-winter, when the stones and trees are as cold as ice, our bodies, except perhaps the tips of the fingers, the toes, and the ears, are always warm. On a winter day we sometimes put our cold fingers to the lips to warm them with our breath.

In fact, the bodies of all animals are more or less warm so long as they are alive. On a wintry day we have all seen the clouds of steam blown from the nostrils and rising from the warm body of a hard-working horse.

6. The Body compared to a Locomotive. The body is, in some respects, like a locomotive. The bones and muscles correspond to the machinery, and the food we eat to the fuel that is used in running it. When the engine is to be used, the fireman puts fuel into the furnace, and soon the water in the boiler is heated and expands into steam. The piston begins to work. This moves the connecting rods and wheels. And so the locomotive is set going by means of the fuel which was put into the furnace.

Something not unlike the action of the locomotive occurs in our bodies. We take food, and it passes into the stomach. By means of that food we are kept warm, muscular force is developed, and our limbs and other parts are made to work, just as the parts of the engine are set in motion by means of the fuel.

7. The Body as a Self-Repairing Machine. The human body and the locomotive are alike in another respect, — both are all the time wearing out. There is an important difference, however, between the two. The locomotive when badly worn must be taken to pieces and repaired by the machinist.

The human body, on the other hand, is constantly repairing itself. We take food not only to warm us and to give us muscular force, but also for the building up and repairing of our bodies.

Remember, then, that the body far surpasses the engine in the perfection of its mechanism, inasmuch as it is a self-repairing machine.

CHEMICAL COMPOSITION OF THE BODY

8. Chemical Elements in the Body. There are about seventy different substances which, when pure, cannot be broken into any simpler forms of matter. These are called **elements.**

The greater number of substances we see around us are compounded of two or more elements. These compounds may be broken up into simple elements by heat, and by various other means.

Our bodies are almost entirely composed of thirteen of the seventy elements. Among these are **oxygen, hydrogen, nitrogen, carbon,** and **iron.**

Oxygen, hydrogen, and nitrogen, which are gases in their uncombined form, make up three fourths of the weight of the whole human body.

Carbon, which exists in an impure state in charcoal, forms more than one fifth of the weight of the body.

We must keep in mind that, with slight exceptions, none of these elements exist in the body in their elementary form. They are combined in various proportions to make compounds which, as a rule, do not resemble the elements of which they are made up. Thus, oxygen and hydrogen unite to form water, and water forms more than two thirds of the weight of the whole body.

9. Organic Compounds. There is in the human body a series of compound substances which require the agency of living structures for their formation. They are built up from the elements or from simple mineral compounds by plants, and are called **organic compounds.**

Animals take as many of these organic substances as they require and build them up into the materials of their own bodies, which process often results in the formation of still more highly organized forms.

10. The Three Great Classes of Organic Compounds. The principal organic compounds found in the body or in our food are usually divided into three great classes: (1) **proteids** (albuminous substances), (2) **carbohydrates** (starches, sugars, and gums), (3) **fats.**

The **proteids,** the type of which is egg albumin, or the white of egg, are found in muscle and nerve, in glands, in blood, and in nearly all the fluids of the body.

NOTE. — The proteids, because they contain the element nitrogen while the others mentioned above do not, are frequently called *nitrogenous*, and the other two are known as *non-nitrogenous* substances.

The extent to which these three great classes of organic materials of the body exist in the animal and vegetable kingdoms, and are utilized for the food of man, will be described in the chapter on food (Chapter IV).

The **carbohydrates** are formed of carbon, hydrogen, and oxygen, the last two in the proportion to form water. Thus, we have animal starch, or glycogen, stored up in the liver. Sugar, as grape sugar, is also found in the body.

The **fats** contain the same three elements as the carbohydrates, but in quite different proportions. There are three chief fats present in the body.

11. Inorganic Salts. A large number of the elements unite one with another to form **inorganic salts.** Thus, sodium and chlorine unite to form common salt, which is found in many of the tissues and fluids of the body.

Again, certain compounds of lime and soda make up more than half the material of the bones.

Compounds of iron are also found in small quantities in the coloring matter of the blood, in the ash of bones, in muscles, and in other tissues.

CELLS AND PROTOPLASM

12. Cells. All living things, whether plants or animals, are made up either of a single **cell** or of countless numbers of **cells.**

The human body is built up of these minute structures known as cells and the things which the cells have made. These cells are so small that we must use a powerful microscope to see them at all.

In a general way we may describe a cell as a tiny mass of jelly in which floats another still smaller mass of slightly different composition, called the **nucleus** of the larger one.

Cells are of various shapes and sizes, spherical, flat, and threadlike. Thus, we shall learn in a succeeding chapter

about the rounded cells, or corpuscles, which float in the blood, and of the flattened cells which can be scraped from the tongue.

13. Variety of Work done by Cells. Some cells can change their forms, as those of muscle; other cells make fluids which help us to digest our food. The outer layer of cells, known as the skin, forms a protective coat to the body. The liver cells manufacture or secrete the bile, and the bone cells help to make the bones.

Millions of blood cells do their work and perish every day, while the brain cells act in some mysterious way to help us to think.

In short, **our very life exists in the cell.**

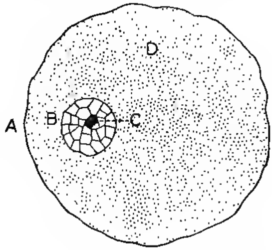

FIG. 1. Diagram of a Cell.
A, cell wall; *B*, nucleus; *C*, nucleolus; *D*, protoplasm of cell body.

14. Cell Life as shown by the Amœba. The work done by cells is well shown in the life history of the **amœba**, a tiny creature not more than $\frac{1}{100}$ of an inch in diameter and found in water containing decaying matter.

If we use a microscope powerful enough to magnify a pin's head into the size of a bicycle wheel, we find that this bit of life appears as a mass of jellylike substance with little grains within it. This jelly is known as **protoplasm**, meaning the primitive or first stuff. Within the amœba may sometimes be seen a round spot known as the **nucleus.**

With the aid of the microscope the life of the amœba, as it is lived in a drop of water, can be studied. It creeps about, it changes its shape, it selects and digests its food, it breathes in oxygen from the air in the water and

gives forth waste material. When the amœba grows to a certain size it divides into two parts, each of which becomes an amœba in itself. In every drop of our blood certain cells, the white blood corpuscles, may be found, even smaller than the amœba and not unlike it in structure.

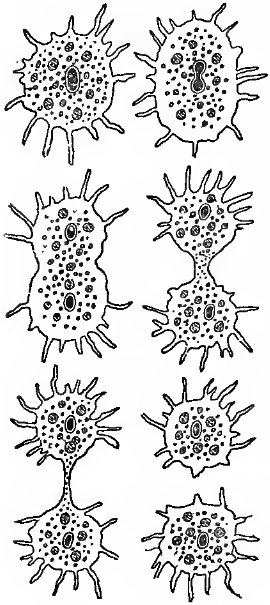

FIG. 2. Diagram showing an Amœba in Successive Stages of Division.

The dark spot is the *nucleus*. The light and somewhat rounded clear spots are more or less sharply defined cavities filled with fluid, and are known as *vacuoles*.

15. The Nature of Protoplasm. Besides proteid, and usually a small amount of carbohydrates and fat, **protoplasm** contains much water in which are dissolved small quantities of mineral substances. Our bodies, as we have just learned, are made up of exactly these same substances, — proteids, carbohydrates, fats, water, and mineral salts. They are contained in the **protoplasm**, or **living matter**.

Finally, we must remember that to manifest life, protoplasm, **the essential material of all living things,** whether plants or animals, must come in contact with oxygen and water and must be warmed to a certain temperature.

16. How Energy is set Free by Protoplasm. Coal, as we know, is the hardened vegetable deposit of forests that lived and died in past ages. If we set fire to coal, its energy is set free or awakened from its long rest like the sleeping princess

in the fairy tale. We can use this energy to produce light, heat, or electricity, or to do work.

In other words, energy, originally derived from the sun, was stored up in the coal and hidden for countless years until changed by burning into the energy of heat, movement, light, and electricity.

So it is with the warm, living, wet protoplasm of our bodies, in the presence of oxygen. It is ever being burnt or broken up into simpler compounds. The energy thus released may show itself as heat or motion. It is for this reason that our bodies are warm and that we have the power of movement.

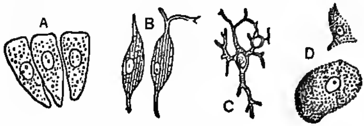

FIG. 3. Various Forms of Cells.

A, columnar cells found lining various parts of the intestines (called *columnar epithelium*); *B*, cells of a fusiform or spindle shape found in the loose tissue under the skin and in other parts (called *connective-tissue cells*); *C*, cell having many processes or projections — such are found in some kinds of connective tissue; *D*, primitive cells composed of protoplasm with nucleus, and having no cell wall. All are represented about 400 times their real size.

Experiment 1. *To examine a typical nucleated cell.* A colorless human blood corpuscle is a typical nucleated cell. Wind a piece of twine tightly around the last joint of a finger. Prick the skin with a clean needle. A drop of blood will flow. Dilute it with a drop of water, or still better, with a few drops of very dilute acetic acid. Spread the diluted blood on a piece of glass and put under a cover glass. Examine with a compound microscope.

A large number of red corpuscles may be seen and with some patience one or more colorless cells. An internal rounded body in the colorless cells may become visible, which is the *nucleus*.[1]

[1] Place a drop of carmine fluid on the slide close to the edge of the cover glass and press a piece of blotting paper against the opposite edge to absorb a little of the liquid. When the blood under the microscope is thus stained with carmine fluid, the nucleus is generally more deeply stained than the rest of the corpuscle.

THE PRINCIPAL TISSUES OF THE BODY

17. The Tissues of the Body. A house, as we all know, is built of timbers, bricks, stone, cement, glass, iron, and other material, properly arranged and adjusted to endure wear and tear, as well as for the convenience and comfort of its occupant.

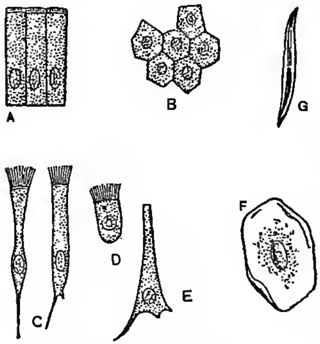

FIG. 4. Various Kinds of Epithelial Cells.

A, columnar cells of intestine; *B*, polyhedral cells of the conjunctiva; *C*, ciliated conical cells of the trachea; *D*, ciliated cell of frog's mouth; *E*, inverted conical cell of trachea; *F*, squamous cell of the cavity of the mouth, seen on its broad surface; *G*, squamous cell, seen edgeways.

In a general way we may say that our bodily houses are built of cells of various sizes and shapes, arranged in groups. These sets of cells compose the **tissues** or materials, and each tissue is distributed through different parts of the body in order to do its special work.

In following chapters we shall learn of two of the most important of these tissues, the **nervous** (Chapter X) and the **muscular** (Chapter III), — the "master tissues," so called because it is by them that the active life of the individual is carried on.

In the next chapter, the **osseous tissue,** or **bone,** will be described.

18. The Epithelial Tissues. One of the simplest of the tissues in the body is called **epithelium,** and its cells are called epithelial cells. It serves as a lining of various cavities,

a covering for the surface of the body, and the essential part of various organs called glands.

There are several varieties of this tissue. Thus, we have the flat cells of the outer skin and the lining of the mouth, the pear-shaped cells in the lining of the stomach and the intestines, and cells with fine, threadlike fringes, called cilia, found in the lining of the air passages (Sec. 225).

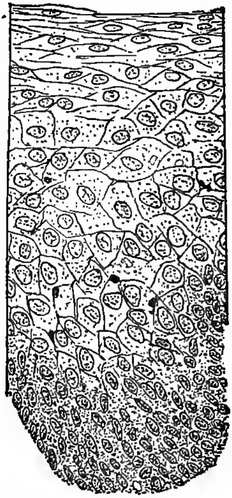

FIG. 5. Cross-Section of Epithelium from the Œsophagus.

Experiment 2. *To examine one form of epithelium (squamous).* Gently scrape the inside of the lips or cheek with an ivory paper knife. Place a tiny portion of the substance thus obtained upon a glass slide. Cover it with a thin cover glass, and if necessary add a drop of water. Examine with the microscope, and the irregularly formed (squamous, or pavement) epithelial cells may be seen.

Experiment 3. *To examine another form of epithelium (ciliated).* With the back of a knife blade gently scrape a little of the membrane from the roof of a frog's mouth. Transfer to a glass slide and add a drop of salt solution. Place over it a cover glass with a hair underneath to prevent pressure upon the cells. Examine with a microscope under a high power. The cilia move quite rapidly while they are fresh (Sec. 225).

19. The Connective Tissues. Just as certain cells develop into masses of cells which we call muscle, brain, and skin, so other cells are set apart to produce tissues by which the frame of the body and its organs are molded and held together. They are called **connective tissues.** They form a

sort of flexible frame for the body and may be said to serve as packing, binding, or supporting tissues. This name includes tissues which vary greatly in their appearance.

20. Connective Tissues with White and Elastic Fibers. If we take a bit of well-cooked corned beef and tease it apart with a needle, we shall find something that looks like the fluff of cotton wool. This is one kind of connective tissue. Now, if we look at the tiniest fibrils of the beef under the microscope, we shall see wavy bundles of white fibers running in all directions. These are known as **white fibrous tissue.** Across these bundles run other fine fibers which branch and coil up like a broken spring and are highly elastic. These are known as **yellow elastic tissue.**

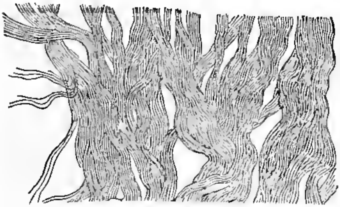

FIG. 6. White Fibrous Tissue.
Highly magnified.

The connective tissue with white fibers sometimes forms a very thin sheet, as in the delicate covering of bone known as the periosteum, or it may be made up into ropelike bands, as in the ligaments of joints and the tendons of muscles. It is the connective tissue with the yellow elastic fibers which makes the coats of the arteries, and certain ligaments, elastic.

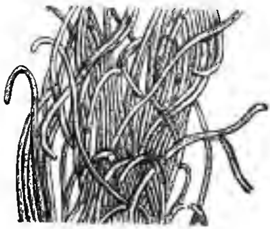

FIG. 7. Yellow Elastic Tissue.
Highly magnified.

21. Areolar Tissue. This is a form of connective tissue which makes a protective covering for important organs. It consists of bundles of delicate fibers which interlace and cross

one another, forming irregular spaces or meshes. These little spaces, in health, are filled with fluid that has oozed out of the blood vessels.

22. Fatty Tissue. The connective tissue sometimes becomes filled with fat. It is then called **fatty** or **adipose tissue.** The fat is deposited as tiny drops of oil within the tissue cells. The fat cells are then bound together by connective tissue into little lumps, which we are able to find on picking a bit of suet to pieces.

Fatty tissue is usually plentiful beneath the skin, in the marrow of bones, on the surface of the heart, and in many other parts of the body.

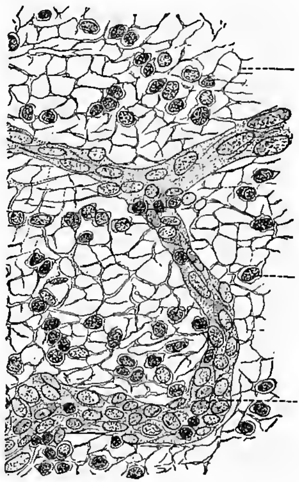

FIG. 8. Connective Tissue from a Lymphatic Gland.

Consisting of a very fine network of fibrils, around which are cells of various sizes.

23. Cartilage or Gristle. Cartilage, or gristle, is a form of connective tissue which under the microscope is seen to consist of a matrix or base in which cells are imbedded, either singly or in groups. It is tough, flexible, and highly elastic. Sometimes the base contains a network of white or elastic fibers.

24. Some Technical Words explained. It is plain that a watchmaker would not be able to understand the working of a watch unless he first made himself acquainted with its various parts. So it is with the study of our bodies. We must know something about their structure before we can understand how they act and move, or, in one word, live.

The science which tells us about the structure, form, and position of the different parts of the body is called **anatomy.**[1]

Take the stomach for an illustration. If we learn what it is, where it is, how it looks, its shape, size, and general appearance, this is its **anatomy.**

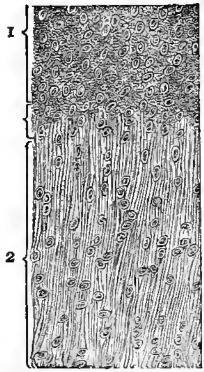

FIG. 9. Longitudinal Section of Cartilage.

Magnified about 650 times.

Showing (1) cartilage with matrix and cells; (2) cartilage with matrix containing cells and white fibers.

The science which explains the uses or functions of the different parts of the body is called **physiology.**

If we learn for what special purpose the stomach is made, just what its different parts do, and how they do it, this is its **physiology.**

Now, if we would learn how to take care of the different parts of the body and how to keep them in good health, we may do this by the study of **hygiene,**[2] or the science which tells us about health.

An **organ** is a part of the body which does a special work. Thus, the eye is an organ of sight, the nose of smell, the stomach of digestion, and the lungs of breathing.

The special work which an organ has to do is said to be the **function** or use of that organ; thus, it is the function of the eye to see, and of the liver to secrete bile.

[1] The word "anatomy" comes from two Greek words meaning a cutting through, or dissection, that is, the act of cutting an animal in pieces for the purpose of study.

[2] The word "hygiene" is derived from the name of the Greek goddess Hygeia, who is said to have watched over the health of the people.

QUESTIONS ON THE TEXT

1. What branch of school work are we now to study? 2. Why does this study appeal to every thoughtful young person? 3. What can you say about the importance of the study? 4. What great fact should we realize? 5. What questions naturally suggest themselves to thoughtful persons? 6. Is some part of our bodies always in motion? 7. What power has every living animal? 8. How do you know that all living animals are more or less warm? 9. How does the body resemble a locomotive? 10. Can you tell where the comparison fails?

11. Of how many chemical elements is the body composed? 12. Mention five of the more important elements. 13. What is meant by organic compounds? 14. What are the three great classes of organic compounds? 15. What is meant by the proteids? 16. Of what are the carbohydrates formed? 17. What can you say of the amount of fat in the body? 18. What is meant by the inorganic salts? Illustrate. 19. Of what are all living plants and animals made up? 20. How will you define a cell?

21. What variety of work is done by cells? 22. What is an amœba? 23. What can be seen of the life of the amœba with the aid of the microscope? 24. Of what is protoplasm composed? 25. How is energy set free by protoplasm? 26. To what may we roughly compare the tissues of the body? 27. What are called the two "master tissues"? 28. What can you say about the epithelial tissues? 29. What general purpose do the connective tissues serve?

30. What is meant by white fibrous tissue? 31. What is yellow elastic tissue? 32. Of what use are these two kinds of connective tissues? 33. Describe areolar tissue and explain its use.

34. Describe fatty tissue and state where it is found. 35. What is meant by cartilage, or gristle? 36. What is meant by anatomy? physiology? hygiene? 37. Give one illustration to make plain each word. 38. What is an organ? Illustrate. 39. What is meant by the function of an organ? Illustrate.

CHAPTER II

THE BONY FRAMEWORK

5. The Skeleton. Every animal must have some kind of framework or support to give its body form or shape. This framework in most animals is chiefly made up of bones.

This bony support is called the **skeleton**, meaning a dried body. It is to the body what the ribs are to a ship, or what the frame is to a house.

Every one is familiar with the picture of the human skeleton. It shows us how the bones look when properly prepared and held in place by wires. There are in all two hundred and six separate bones in the adult skeleton. The teeth are not bones, but are a part of the skin.

The bones give firmness, strength, and protection to the soft tissues and vital organs, and form, as it were, the foundation upon which our bodies are built.

26. How Bone is made up. Bone is a hard and strong substance, made up of animal matter united with certain mineral earths, chiefly compounds of lime. The earthy part of bone makes up about two thirds of its weight, and the animal portion the other third. The lime gives hardness and firmness to the bones, while the animal substance makes them elastic, tough, and flexible.

In childhood the bones have more animal matter than those of the adult; hence a child's bones do not break easily, and, when broken, soon knit together.

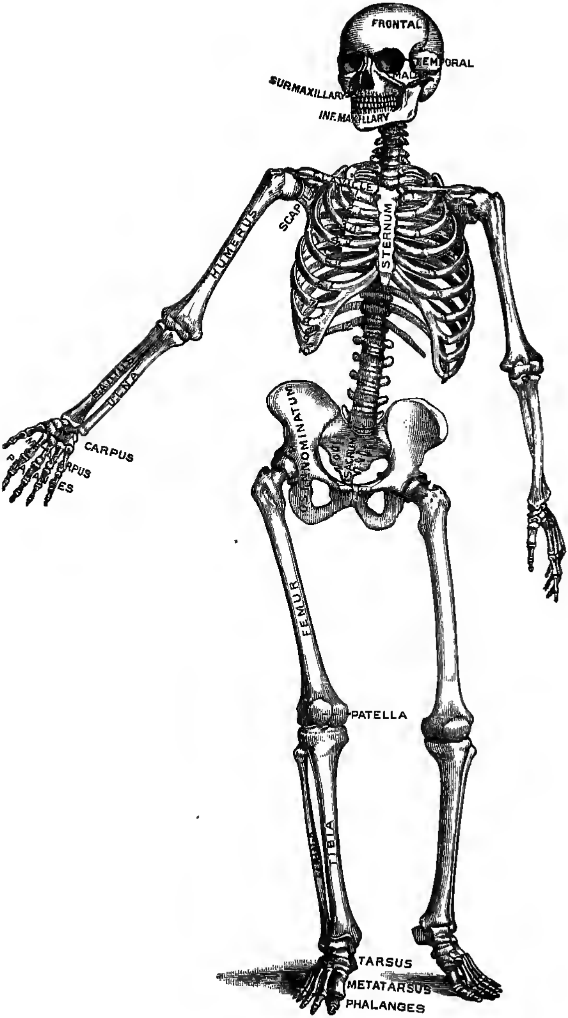

FIG. 10. The Skeleton.

In old age there is more lime in the bones in proportion to the animal matter; hence they are more brittle and more easily broken than in early life. If broken they unite quite slowly, or not at all.

Experiment 4. *To show the earthy or mineral part of bone.* Put a large soup bone on a hot, clear fire until it is at a red heat. At first it becomes black, but after a time it turns white.

Examine the bone after it is cool. The animal matter has now been burnt out, leaving the earthy or mineral part, a white, brittle substance showing every outline of the bone.

FIG. 11. The Fibula tied into a Knot after the Mineral Matter has been dissolved by Acid.

Experiment 5. *To show the animal part of bone.* Scrape and clean a chicken's leg bone, part of a sheep's rib, or any other small, slender bone. Add one fourth of a cupful of muriatic acid to a quart of water and place the mixture in a wide-mouthed bottle or glass fruit jar. Soak the bone in the acid mixture for a few days, adding a little more acid from time to time.

The mineral matter is slowly dissolved, and the bone, although retaining its original form, becomes so soft as to be readily cut. If the experiment be carefully performed, the bone may even be tied into a knot.

27. General Structure of the Bones. Take a long bone, like that from a sheep's leg or even a part of a beef shin bone, and saw it lengthwise. Note that the ends are soft and spongy, while the shaft is hard and compact. The central cavity runs almost the whole length of the bone. It is filled, in life, with a soft, fatty substance called marrow.

If the bones were solid, they would be much too heavy for ordinary use. A bone may be hard as a rock on the outside, on account of its thin, dense layer of compact bony tissue, and yet be light because of its cavity and the trellis work of loose, spongy texture at the ends.

A cylindrical bone is not weak although it is hollow. The pillars of steel bridges, the posts for the support of electric wires, and the frame of a bicycle are made of hollow steel tubes. We all know that stalks of grass and grain are so light and slender that they will bend before a light breeze, and yet they are strong enough to bear their load of seed.

FIG. 12. The Right Femur sawed in Two Lengthwise.
Showing arrangement of compact and spongy tissue.

Experiment 6. Saw in two, lengthwise, a part of a beef shin bone, or a portion of a sheep's or a calf's leg, including, if convenient, the kneejoint. Boil, scrape, and carefully clean one half. Note the compact and spongy bone, the shaft, etc.

Experiment 7. After the flesh has been cut from the second half, note the pinkish white appearance of the bone, the marrow, etc. Knead a small piece of the marrow in the palm; note its oily appearance. Contrast this fresh bone with an old, dry one picked up in the field.

NOTE. — While waiting for class use, fresh bones should be kept in a cool place, carefully wrapped in cloths moistened with listerine, dilute carbolic acid solution, or even glycerin solution, — an ounce to one pint of water.

28. The Shape of Bones. Bones are of many different shapes, according to the uses to which they are put. Some are long, with hollow shafts, as the bones of the arm and the leg; others are short or irregular, to give strength, as the bones of the fingers, the toes, and the spine.

Some bones are flat, for protection and to cover cavities, like the bones of the skull and shoulder blades; while others

are of various odd shapes and sizes, and hence are called irregular, as the bones of the wrist, the skull, and the ankle.

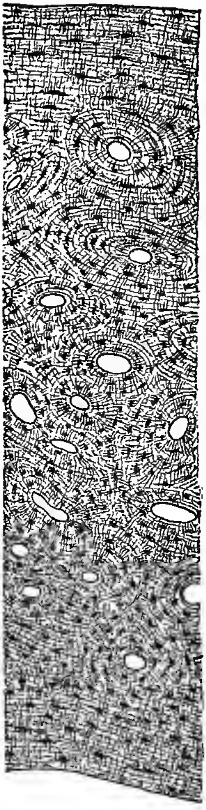

FIG. 13. Cross-Section from Shaft of a Long Bone.

Magnified 56 times.

Little openings (Haversian canals) are seen, and around them are arranged rings of bone with little dark spaces (*lacunæ*), from which branch out fine dark lines (*canaliculi*).

29. **How Bone looks under the Microscope.** Bones have a great number of very small blood vessels, which pass through tiny canals, **Haversian canals**, in the bones, carrying materials for their nourishment and growth. Round these canals the spiderlike **bone cells** lie in small cavities, **lacunæ**, which are arranged in circles or rows. These cavities are joined to one another and to the canal which they surround, by other extremely fine canals, **canaliculi**. The nourishing fluid of the blood, **lymph**, soaks through these minute cavities to all parts of the bone.

The hard part of the bone lies around the Haversian canals in layers, **lamellæ**, which are interrupted at intervals by the lacunæ and canaliculi.

When a thin section of hard, dry bone is examined under the microscope, the Haversian canals are seen as holes surrounded by lamellæ of bone. The lacunæ and canaliculi, filled with dust and air, appear as dots and lines. The bone cells and marrow have entirely disappeared.

NOTE. — A very delicate layer of connective tissue, called the **periosteum**, closely adheres to every part of the

bones, except at the joints, where it is protected with cartilage. Shreds of the periosteum may be stripped off with forceps, if the bone is soaked for some time in water. This membrane plays a very important part in the formation, growth, and repair of bones, as the blood vessels of bones form a network in them before entering the Haversian canals. It is therefore of great surgical importance. Bones have been removed, leaving the periosteum, within which remarkable tissue the entire bone has grown again.

THE BONES OF THE HEAD

30. The Skeleton and its Three Main Divisions. The **skeleton**, or bony framework of the "house we live in," consists of the bones of the **head**, the **trunk**, and the **limbs**.

31. The Bones of the Head. The bones of the **head** are usually described in two parts,—those of the **cranium** and those of the **face**. Together they form the **skull**.

FIG. 14. The Skull. (Front view.)

A, frontal bone; *B*, parietal bone; *C*, temporal bone; *D*, sphenoid bone; *E*, malar bone; *F*, upper jawbone; *G*, lower jawbone.

The general shape of the head is that of an arch. The arch is the strongest shape in which the skull could be made, just as the arched bridge is the strongest shaped bridge which can be made to bear the heavy loads that pass over it.

32. The Bones of the Cranium. The greater part of the skull consists of a rounded, bony box, the **cranium**, which holds and protects the brain under its domelike roof.

It is made up of eight bones closely locked together by seams, or sutures, somewhat like the dovetailing used by carpenters.

These eight bones are:

1 **Frontal** (forehead)	1 **Occipital** (back of head)
2 **Parietal** (side of head)	1 **Sphenoid** (wedge-shaped)
2 **Temporal** (temples)	1 **Ethmoid** (sievelike).

The **frontal** bone forms the forehead.

The **parietal** bones form part of the side walls, top, and back of the skull.

The **temporal** bones lie round each ear and form the temples on either side.

The **occipital** bone forms the lower part of the back of the skull. This broad, thin bone rests on the topmost bone of the backbone, and is pierced by a large oval opening where the spinal cord joins the brain.

The **sphenoid**, or wedge bone, is wedged in between the bones of the cranium and those of the face, and serves to lock together fourteen bones.

The **ethmoid**, or sievelike bone, so called because it is full of holes like a sieve, lies in the base of the skull between and above the eye cavities just at the root of the nose.

33. The Bones of the Face. All bones of the **face**, except the lower jawbone, are firmly fixed to each other and to the bones of the cranium.

The **face** contains fourteen bones, viz.:

2 **Malar**, or **cheek bones**	2 **Palate bones**
2 **Nasal**, or **nose bones**	2 **Lachrymal bones**
2 **Upper maxillary**, or **upper jawbones**	1 **Vomer**, or **plowshare bone**
1 **Lower maxillary**, or **lower jawbone**	2 **Turbinated**, or **spongy bones**.

34. The Larger Bones of the Face. Under the orbits are the two **malar**, or cheek bones. Some races have much

higher cheek bones than others. Indeed, some races, like the American Indians, are recognized by the peculiarity in the size and shape of their cheek bones.

The two **nasal** bones form the hard part, or bridge, of the nose.

The two **upper jawbones** form a part of the roof of the mouth and the floors of the orbits. In them is fixed the upper set of teeth.

The lower set of teeth is fixed in the **lower jawbone,** which moves by means of a hinge joint, thus allowing the opening and shutting of the mouth.

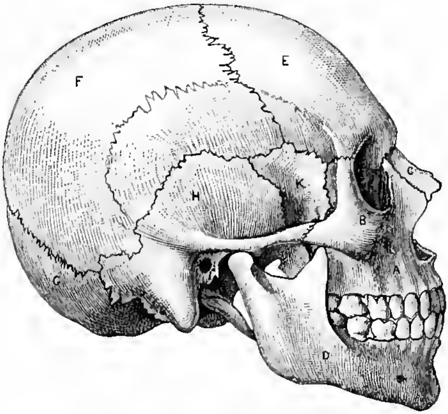

FIG. 15. The Skull. (Side view.)

A, upper jawbone; *B*, malar bone; *C*, nasal bone; *D*, lower jawbone; *E*, frontal bone; *F*, right parietal bone; *G*, occipital bone; *H*, temporal bone; *K*, sphenoid bone.

35. The Smaller Bones of the Face. The remaining bones of the face are small. Two bones, forming the back part of the roof of the mouth, are called the **palate** bones. Sometimes infants are born with a "cleft palate." This means that the two palate bones have not been joined together.

Two little bones, made like little troughs, carry the tears from the eyes to the nose. They are in shape somewhat like the finger nails, and are called the **lachrymal** bones, from a Latin word meaning tear.

The **vomer**, or plowshare bone, so called from its resemblance to the share of the farmer's plow, is situated between the nostrils.

Two little scroll-like bones within the nose cavity are known as the twisted or **turbinated** bones.

36. How the Bones of the Head are joined together. The bones of the head are joined together in a peculiar way. Each bone has uneven edges, somewhat like the teeth of a saw, which fit into the edges of the bone to which it is joined.

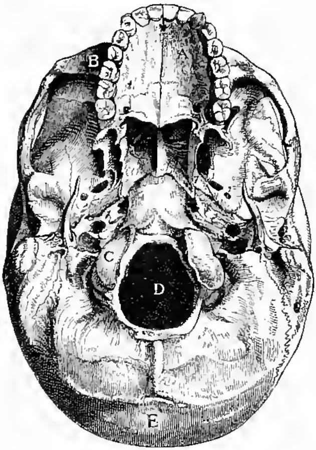

FIG. 16. The Base of the Skull.

A, palate process of upper jawbone; *B*, zygoma, forming zygomatic arch; *C*, condyle, for forming articulation with atlas; *D*, foramen magnum; *E*, occipital bone.

In adults these edges fit into each other and grow together, resembling the dovetailed joints in a cabinetmaker's work. They are called *sutures*, from a Latin word which means a sewing or a seam.

In infancy some of the bones of the skull do not meet, and the throbbing of the brain beneath them at the top of the head, like the bubbling of a spring, is easily seen. These openings are called *fontanelles*, meaning little fountains. The bones of the skull are not wholly united till the child reaches adult life.

37. The Hyoid Bone. Under the lower jaw is a little horseshoe-shaped bone, called the **hyoid** bone because it is shaped like a Greek letter (υ). The root of the tongue is fastened to

its bend, and the larynx is hung from it as from a hook. To this bone are attached muscles which move the tongue. The hyoid, like the kneepan, is not connected with any other bone.

Experiment 8. *To locate the hyoid bone.* With the neck resting in its natural position, gently grasp the front of the throat with the thumb and forefinger just above the "Adam's apple." The hyoid bone can be plainly felt on a level with the lower jaw and about one inch and a half behind it (Fig. 173).

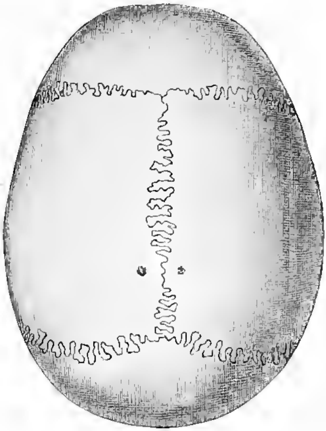

FIG. 17. The Top of the Skull, showing the Sutures.

THE BONES OF THE TRUNK

38. The Trunk and its Two Cavities. The **trunk** is that part of the body which supports the head, and to which the arms and the legs are attached. It has two important parts, or cavities.

The upper part, called the **thorax,** or chest, is like a basket or cage of bone. It is formed by the breastbone in front, the ribs and a part of the backbone behind. It contains the lungs and the heart.

The lower part, or **abdomen,** holds the stomach, liver, intestines, kidneys, and other important organs.

The chest and abdomen are separated by a muscular partition known as the **diaphragm,** which serves as the chief muscle in breathing.

39. The Bones of the Trunk. The principal bones of the trunk are those of the **spine,** the **ribs,** and the **hips.**

There are fifty-three bones in the **trunk**, and they are thus arranged.

I.	**The Spine, 26 bones**	**7 Cervical, or neck vertebræ** **12 Dorsal, or back vertebræ** **5 Lumbar, or loin vertebræ** **1 Sacrum, or sacred bone** **1 Coccyx, or cuckoo bone**
II.	**24 Ribs**	**14 True ribs** **10 False ribs**
III.	**1 Sternum, or breastbone**	
IV.	**2 Hip bones**	

40. The Spine. The **spine**, or backbone, serves as a support for the whole body. It is made up of a number of separate bones called **vertebræ**, between which are placed elastic pads, or cushions, of cartilage.

These pads not only serve to bind the vertebræ firmly together, but also help to break the force of any shock or jar which the spine may receive, just as the rubber tires of a carriage, an automobile, or a bicycle lessen the jolting which would be felt without them.

The spine forms a pillar, or column of bones, tapering towards the head. The lower ones are larger and stronger to enable them to bear the weight of those above them.

At the top are seven **cervical**, or neck vertebræ; below them are the twelve **dorsal**, or back vertebræ, from which spring the ribs.

The next five bones, called the **lumbar**, or loin vertebræ, are thicker and larger.

41. The Sacrum and Coccyx. The twenty-four vertebræ rest on and above a strong, three-sided bone called the **sacrum**, or sacred bone, which is wedged in between the hip bones like the keystone of an arch. This bone supports the spine and breaks the force of sudden shocks.

Joined to the lower end of the sacrum is a little, tapering bone, made up of several little bones, called the **coccyx**. It is so named from its fancied resemblance to the beak of a cuckoo.

42. How the Bones of the Spine are arranged. Each bone, or vertebra, of the backbone has a hole within it, and the separate bones are so placed, one above the other, that these holes form a continuous tube or canal, down which passes the spinal cord. Imagine a number of spools placed one on another. The central hole through each would be exactly over the other, and there would be one long tube or channel through the whole string of spools. In this bony canal the spinal cord lies protected from injury.

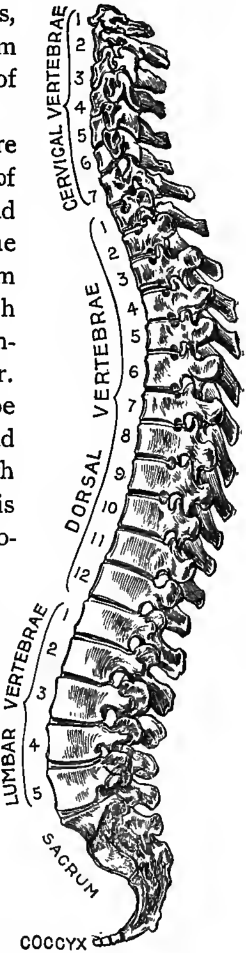

FIG. 18. The Spinal Column.

From each vertebra projects a spine or thorn of bone, to which are fastened muscles which keep the flexible backbone erect and lift the head and shoulders. The row of spines along the whole length of the backbone forms a ridge, which can be easily felt by pressing with the fingers up and down the middle of the back.

43. The Wonders of the Spine. The spine is built in a most curious and wonderful manner, — firm, and yet elastic; so stiff that it will bear

a heavy weight and yet bend like rubber. It is a tapering pile of odd-shaped bones, so admirably planned and so wonderfully put together, that the delicate brain resting upon it, and the spinal cord hidden within its bony canal, are not often hurt.

The most daring acrobat rarely breaks the bones of his spine or puts them out of place. It is not an uncommon thing to see show people bend their backs until they can put their heads on the ground, or clasp their legs around their necks.

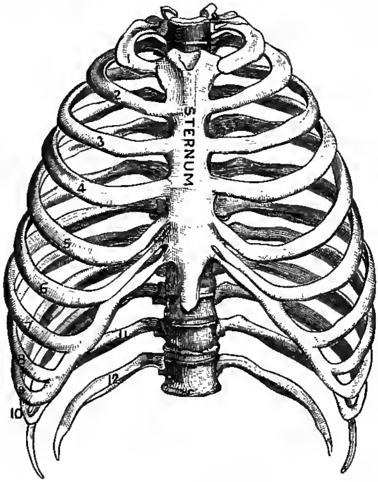

FIG. 19. Thorax. Anterior view.

Experiment 9. *To illustrate the movement of torsion in the spine.* Sit upright with the back and shoulders well applied against the back of a chair. Note that the head and neck can be turned as much as 60° or 70°. Now bend forward so as to let the lumbar vertebræ come into play, and the head can be turned 30° farther.

44. The Ribs. The **ribs** are long, flat, and curved bones which bend round the chest somewhat like the hoops of a barrel. There are twenty-four ribs, — twelve on each side.

The ribs are joined to the backbone behind, and most of them are joined in front, directly or indirectly, to a flat, narrow bone, which is shaped somewhat like an ancient sword or dagger. It forms the middle front wall of the chest and is called the **sternum**, or breastbone.

Counting from the neck, the first seven pairs are called the **true ribs**. They are all joined directly to the breastbone.

The five lower pairs, known as the **false ribs**, are not joined to the breastbone at all. Cartilages connect the first three of them with each other, and with the last of the true ribs.

The lowest two pairs of ribs are often known as the **floating ribs**, because they are not even joined by cartilages, but are quite free in front.

45. The Hips and the Pelvis. The lower part of the trunk is formed by two large, irregular bones, very firm and strong, called the **hip**, or haunch bones. They are joined to the sacrum behind, and to each other in front.

The two hip bones, with the sacrum and coccyx, form a kind of bony basin called the **pelvis**, which contains and protects several important organs.

Each hip bone has a cup-shaped cavity on its side, into which the rounded head of the thigh bone fits. It is called the **acetabulum**, meaning vinegar cup, because it has the shape of the vinegar cups used by the Romans.

THE BONES OF THE UPPER LIMBS

46. The Bones of the Upper Limbs. Each of the upper limbs consists of the **shoulder**, **arm**, **forearm**, and **hand**.

The thirty-two bones of each upper limb are usually classified as follows.

Shoulder	**Scapula, or shoulder blade**
	Clavicle, or collar bone
Arm	**Humerus, or arm bone**
Forearm	**Ulna**
	Radius
Hand	**8 Carpal, or wrist bones**
	5 Metacarpal bones
	14 Phalanges, or finger bones

47. The Bones of the Shoulder and Arm. There are two bones in the shoulder, and they serve to fasten the arm to the trunk. These are the **scapula**, or shoulder blade, and the **clavicle**, or collar bone.

The **shoulder blade** is a large, flat, three-sided bone, which is placed on the upper and back part of the chest. On the outer side it has a saucerlike cavity on which the rounded head of the arm bone rests.

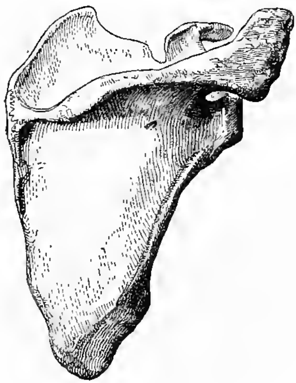

FIG. 20. The Scapula.

The **collar bone** is a long, narrow bone, with a double curve like the italic letter *f*. It serves, like the keystone of an arch, to keep the shoulders wide apart, and thus to allow the arms great freedom of movement. Its inner end is tied to the breastbone, and its outer to the shoulder blade.

The **humerus**, a long, hollow bone, rests against a shallow socket on the shoulder blade. It is joined at the elbow to the bones of the forearm.

48. The Bones of the Forearm. The forearm contains two long, hollow bones, the **ulna** and the **radius.**

The **ulna**, or elbow bone, is the larger of these two bones. It is joined to the humerus by a hinge joint at the elbow. It is on the same side as the little finger.

The **radius**, queerly named because it is supposed to resemble one of the spokes of a wheel, is the long, slightly curved, outer bone of the forearm. It is on the same side as the thumb. Its upper end is fastened both to the ulna and the humerus.

Fig. 21. The Humerus.

The radius is fastened to the ulna in such a manner that it can glide partly round it. This gives us the power of twisting the hand.

Experiment 10. *To illustrate the action of the radius.* Rest the forearm on a table, with the palm up. The radius is on the outer side (thumb) and parallel with the ulna. If now, without moving the elbow, we turn the hand as if to pick up something from the table, the radius may be seen and felt crossing over the ulna, while the latter bone has not moved.

49. The Hand. The hand consists of the eight bones of the wrist (carpal), the five long bones of the palm (metacarpal), and the fourteen small bones of the fingers (phalanges). Each finger has three bones, each thumb two. The bones of the fingers are arranged in three rows, as shown by closing the hand.

The twenty-seven bones of the hand are held in place by strong but flexible ligaments. By this beautiful contrivance, the greatest strength and mobility are given to the hand, which is thus fitted for all kinds of work, from grasping heavy hammers to handling the pen, playing difficult music on the piano, and threading the finest needle.

Fig. 22. The Ulna and the Radius.

THE BONES OF THE LOWER LIMBS

50. The Lower Limbs. The general structure and number of the bones of the **lower limbs** bear a striking similarity to those of the upper

limbs. The two sets of limbs, although differing in many points, are built on the same general plan, the one being adapted for grasping and the other for walking.

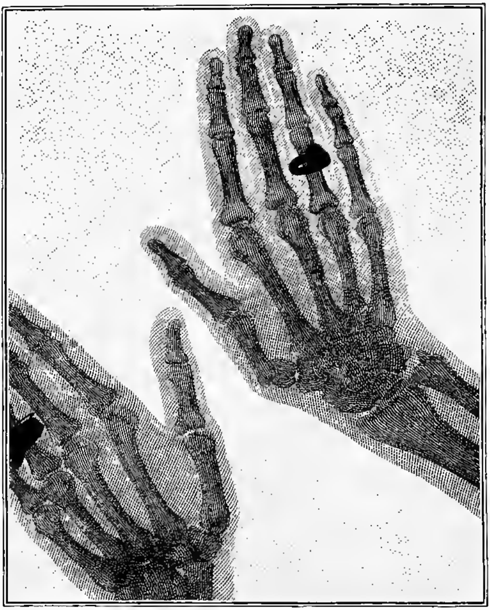

FIG. 23. Bones of the Hand and Wrist, as shown by an X-Ray Photograph. Two rings are plainly shown.

51. The Bones of the Lower Limbs. The lower limb, like the arm, is arranged in three parts, — the **thigh, leg,** and **foot.**

The thirty bones of each **lower limb** are usually classified as follows.

Thigh	**Femur, or thigh bone**			
Leg	**Tibia, or shin bone**	**Foot**	7	**Tarsal, or ankle bones**
	Fibula, or splint bone		5	**Metatarsal, or instep bones**
	Patella, or kneecap		14	**Phalanges, or toe bones**

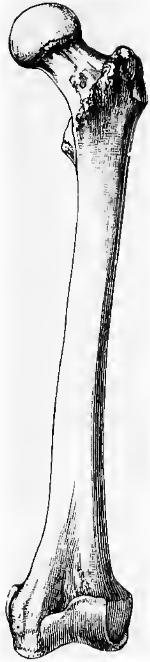

FIG. 24. The Femur.

52. The Thigh Bone. The **femur**, or thigh bone, the largest and heaviest bone in the body, reaches from the hip to the knee. It has a rounded head, which fits into the cup-like cavity in the hip bone which has already been mentioned.

53. The Bones of the Leg. The **leg** consists, like the forearm, of two bones. The larger, a strong, three-sided bone with a sharp edge in front, is called the **tibia**. It is commonly known as the shin bone.

The smaller bone, bound at both ends to the tibia, as a pin is to a brooch, is called the **fibula**, meaning a buckle or clasp. It is a long, slender bone on the outside of the leg, and its lower end forms the outer ankle

Covering the kneejoint in part is a flat, three-sided bone, called the **patella**, or kneepan, which helps to protect the front of the kneejoint.

FIG. 25. The Tibia and the Fibula.

54. The Bones of the Foot. The **foot** consists of twenty-six bones, which are known as the **tarsal** and **metatarsal** bones, and the **phalanges**.

The seven **tarsal**, or ankle bones form the heel, the ankle, and part of the sole of the foot. These bones are tied firmly together by straps, or ligaments, and are strong enough to bear the weight of the body.

The large bone, which projects backwards, is the heel bone. It is connected with the great calf muscles of the leg by a very strong cord, or tendon, called the tendon of Achilles.[1]

The five **metatarsal**, or instep bones correspond to the palm bones of the hand.

The **phalanges** are the fourteen bones of the toes.

55. Why the Foot is built in the Form of an Arch. The foot is built in the form of a half dome or half arch. This is to afford a broad, strong surface for the support of the weight of the body. The bones of the toes and the heel

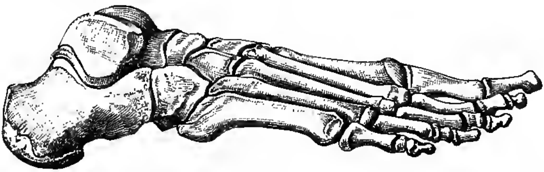

FIG. 26. The Bones of the Foot.

form the piers, while the little bones wedged in between the metatarsal bones and the heel make up the keystone of the arch. This arch gives a certain amount of spring and elasticity to the feet, and hence it is of the utmost importance in preventing jars and jolts.

Experiment 11. Place your bare foot in water and then stand on a dry board. The imprint on the board will show you how much of the foot touches the ground, and thus the extent of the arch.

56. How Bones are joined together. The place where two bones join together is called a **joint** or an articulation.

Joints vary according to the kind and amount of motion. In all joints the essential parts are the same.

[1] The warlike deeds of this famous Greek hero were sung by Homer. According to the story, Achilles received his death wound in the heel, no other part of his body being vulnerable.

The joint end of the bones is smooth, moist, and tipped with a thin layer of cartilage, called hyaline cartilage. This smooth and glistening covering is bathed with a sticky fluid called the **synovial fluid**, so named because it is like the white of a raw egg. This is the liquid often spoken of as "joint oil," furnished by nature to allow the rubbing surfaces to move smoothly over one another, and thus prevent too much wear and tear.

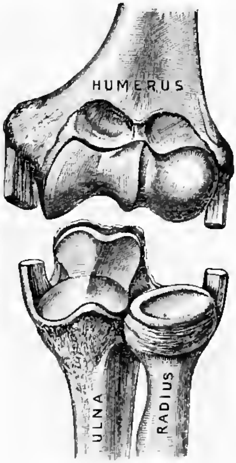

Fig. 27. Showing how the Ends of the Bones are shaped to form the Elbow Joint.

The cut ends of a few ligaments are seen.

57. Different Kinds of Joints. There are two principal kinds of joints, the **imperfect**, or practically **immovable**, and the **perfect**, or **movable**. Thus, the bones of the head, as we have seen, are firmly dovetailed by jagged edges, which grow into each other from infancy. These are known as **imperfect joints**.

Movable joints allow the bones to glide on each other with more or less freedom of motion. They differ according to the motion needed.

Thus, the joint at the hip is called a **ball-and-socket joint**, and is not unlike a child's toy cup and ball, because the rounded head of the thigh bone fits into a socket in the hip bone. The rounded head of the arm bone, as we have learned, works in the shallow, saucerlike cavity of the shoulder blade. Such a joint allows a great variety of motion in almost every direction.

Bones at certain joints are grooved and ridged so that one bone can glide over the other to and fro, like the lid of

a box or a door on its hinges. This is called a **hinge joint**. The elbow joint is a good example of this forward and backward movement; we can only bend and extend it.

Other hinge joints are found at the knee, and between the lower jaw and the cranium. The last permits some motion from side to side, and is therefore called an imperfect hinge joint.

Fig. 28. A Powerful Ligament at the Hip Joint.

Experiment 12. Sit in a chair and extend the right leg. Place the right heel on the floor and turn the foot from side to side. The thigh bone can be felt rotating in the upper part of the thigh. Note that while the thigh bone moves through a small space, that described by the tips of the toes is much larger.

58. How Bones are fastened to Each Other. The bones are fastened together, kept in place, and their movements limited, by tough and strong bands, or straps, called **ligaments**, from a word meaning to bind. They may be seen in the movable joints, — of the calf, sheep, or chicken, — and have the look of white, silvery cords or bands.

Some of the ligaments are as thin as very thin tissue paper; while others, as at the side of the knee, or at the shoulder, are much thicker. Some cross each other, as in the knee-joint; while others go all round the joint, and completely shut it up in a bag. This prevents the bones from being easily dislocated, or slipped out of place.

It is sometimes a difficult matter to carve a fowl, because one has to cut through the ligaments before he can cut the

limbs apart to serve it in pieces. There may be the same difficulty in separating the bones in a shoulder or leg of mutton, because they are held firmly together by ligaments.

59. Use of the Bones. Bones serve many useful purposes. They preserve the general shape of the body. The skeleton, as we have seen, is its framework, which gives protection, leverage, and support to the soft and fleshy parts of our bodies.

Bones protect the soft organs of the body. The bones of the head protect the soft and delicate brain. The ribs inclose the heart and lungs in a large cage of bone.

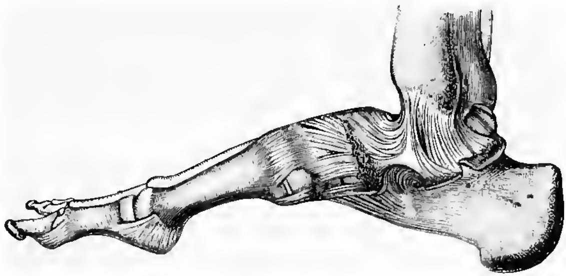

Fig. 29. Ligaments of the Foot and the Ankle.

Passageways and little cavities are hollowed out of solid bone to lodge and shield important organs. There are grooves and canals in the bones which serve to receive and protect tender organs, delicate nerves, and tiny blood vessels.

The surfaces of many bones are fitted with grooves, knobs, and sharp edges to which muscles are fastened. This arrangement of the muscles helps us to stand erect and make the countless movements of the body with ease and quickness.

60. Repair of Broken Bones. When a bone is broken, blood trickles out between the injured parts, and afterwards gives place to a sticky, watery fluid, which gradually becomes thicker, like sirup or jelly. This is slowly replaced by a new bone structure, and forms a kind of cement to hold together the broken ends.

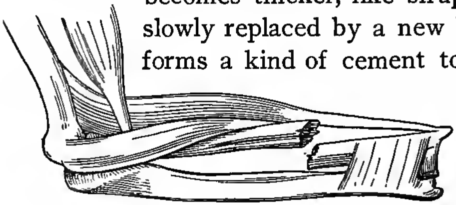

FIG. 30. A Broken Radius.

Nature does not spare her healing cement. The excess bulges out around the place of union, over which a bunch may be felt under the skin for years. In young people, a broken bone will knit together in two or three weeks; while in grown-up people six weeks or more will be required. In aged persons, a broken bone may prove a tedious and often a serious matter.

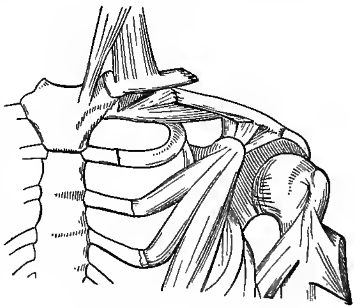

FIG. 31. A Broken Clavicle.

When a bone is broken, the ends tend to "ride" over each other, because the muscles tend to pull the broken portions apart; hence the need of a surgeon to "set" the bone by drawing the injured parts into place, and keeping them in position by splints and bandages properly applied.

After a bone has been once broken, it is fragile for some time, and great care should be taken, especially with children, for fear that it may be broken a second time before it has properly healed (Sec. 405, Figs. 179 and 185).

61. Hints about the Health of Bones. The bones of children are flexible and capable of being bent by long-continued strain, because they contain more animal matter than in later years. Therefore great care must be taken with the positions which children take at home, at school, and elsewhere.

FIG. 32. A Broken Tibia.

Young people should not get into the habit of taking hurtful positions, such as sliding down into the seat, sitting on the foot or on the small of the back. Bending over too much while reading, writing, sewing, practicing on the piano, or doing other work, may cause spinal curvature and round shoulders.[1]

The use of tight and high-heeled boots and shoes cannot be too strongly condemned as both hurtful and ugly. High heels throw the weight of the body forward, and force the foot down onto the toes. This will in time not only crowd the toes out of proper shape, causing tender feet, corns, bunions,

[1] Children who go to school at six or seven years of age are often compelled to sit on a badly shaped chair, sometimes with no support for the back. The muscles become tired and the child leans to one side, usually to the right.

A narrow space between the seat and the desk obliges the child to push between them, so that, in girls particularly, a drag is exerted on one shoulder; or the skirts form an uneven cushion, tilting the spinal column out of the perpendicular. Even in grown men and women, occupations requiring a one-sided muscular action affect the vertebræ, and therefore the shape of the spine. In children the much softer bones are still more readily affected.

distorted joints, and ingrowing nails, but, in many instances, tends to make the gait stiff and ungainly.[1]

62. Effect of Alcohol upon the Cell Growth of the Bones. The bones grow mainly during the earlier years of life, and yet they do not reach their full growth until about the twenty-fifth year. It is said that the skull grows even after that age. Now, we know that a person's form depends to a great extent upon the size and shape of his bones, because, as we have seen, they make up the framework of the body. It is plainly evident, then, that the bone cells, which are busily building up the bony tissues while we are young, must not be injured or badly nourished, otherwise our bones may become feeble and stunted in their growth.

FIG. 33. Showing how the Bones of the Skull may be artificially deformed by "Head Binding."

From the photograph of a "triangular" skull found in an Indian grave in Ancon, Peru.

[1] Most deformities of the feet are developed during childhood, while the bones are soft, the ligaments less resistant, and the muscles, together with the other foot structures, are undergoing rapid changes in development.

The power of the foot as a sustainer of the weight of the body is readily understood. The heel, great toe, and outer side of the foot form the three points of a tripod. An outward-crowded great toe decreases the utility of the foot to just such a degree as it is forced from its normal position.

Toeing in is often due to the unconscious effort to lessen the strain on the arch of the foot, produced by badly formed shoes. Few children will toe in if they wear properly shaped shoes.

Alcoholic liquors tend to retard the growth of the cells, bone cells included, and prevent their proper development. Hence alcohol in all its forms is especially injurious to young people, as it checks the cell growth of the bones and thus hinders the building up of the bony framework.[1]

63. Effect of Tobacco upon the Bony Cell Growth. What we have just read of the effect of alcoholic liquors in retarding the cell growth of the bones and thus stunting the bony framework holds good of tobacco. This powerful narcotic is peculiarly injurious to the young, as the bony cell growth is easily disturbed at this time by noxious substances. If the bones are defrauded of their proper building material because the blood sent to nourish their cells is poor in quality or loaded with narcotics, they become undersized or weakened.

A well-developed framework is something to be prized. No thoughtful boy or girl will risk losing it by indulging in the use of tobacco or any other narcotic.[2]

[1] The injurious effect of alcohol on the entire development of the child is evident from the fact that children who drink spirituous liquors are noticeably stunted in growth. — ADOLF FRICK, M.D.

The use of alcoholic drinks exerts an injurious influence upon the mental and physical development of children. — DR. FIEDLER, Superintendent of the Dresden City Hospital, Germany.

[2] Smoking prevents a healthy nutrition of the several structures of the body. Hence comes, especially in young persons, an arrest of the growth of the body, low stature, an unhealthy supply of blood, and weak bodily powers. — DR. J. COPLAND, F.R.S., of England.

Stunted growth, impaired digestion, palpitation, and other evidences of nerve exhaustion and irritability have again and again impressed a lesson of abstinence from tobacco which has hitherto been far too little regarded. — London *Lancet*.

REVIEW ANALYSIS

THE BONES OF THE BODY

- **THE HEAD** (29 bones)
  - I. Cranium (8 bones)
    - 1 Frontal
    - 2 Parietal
    - 2 Temporal
    - 1 Occipital
    - 1 Sphenoid
    - 1 Ethmoid
  - II. Face (14 bones)
    - 2 Malar
    - 2 Nasal
    - 2 Superior maxillary
    - 1 Lower maxillary
    - 2 Palate
    - 2 Lachrymal
    - 1 Vomer
    - 2 Turbinated
  - III. The Ear (6 bones)
    - Hammer
    - Anvil
    - Stirrup
  - IV. Hyoid Bone
- **THE TRUNK** (53 bones)
  - I. Spinal Column (26 bones)
    - 7 Cervical vertebræ
    - 12 Dorsal vertebræ
    - 5 Lumbar vertebræ
    - Sacrum
    - Coccyx
  - II. The Ribs (24 bones)
    - 14 True ribs
    - 10 False ribs
  - III. Sternum
  - IV. Two Hip Bones
- **UPPER LIMBS** (64 bones)
  - I. Shoulder
    - Scapula
    - Clavicle
  - II. Arm
    - Humerus
  - III. Forearm
    - Ulna
    - Radius
  - IV. Hand
    - 8 Carpal
    - 5 Metacarpal
    - 14 Phalanges
- **LOWER LIMBS** (60 bones)
  - I. Thigh
    - Femur
  - II. Leg
    - Tibia
    - Fibula
    - Patella
  - III. Foot
    - 7 Tarsal
    - 5 Metatarsal
    - 14 Phalanges

QUESTIONS ON THE TEXT

1. What is meant by the skeleton, and what are its uses? 2. Of what is bone composed? 3. What experiments illustrate the composition of bone? 4. Explain the general structure of bone. 5. What can you tell of the general shape of bones? 6. How does bone look under the microscope? 7. Name the principal divisions of the human skeleton. 8. Into what parts is the head divided? 9. Mention the bones of the cranium. 10. Describe each bone of the cranium.

11. Give the names of the bones of the face. 12. Describe the larger bones of the face. 13. Describe the smaller bones of the face. 14. How are the bones of the head joined together? 15. Where is the hyoid bone? 16. Of what parts does the trunk consist? 17. Mention the bones of the trunk. 18. Describe the spine in full. 19. How are the bones of the spine arranged? 20. Describe in some detail the ribs.

21. How are the bones of the pelvis arranged? 22. Name the bones of the upper limbs. 23. Describe the bones of the shoulder and arm. 24. Describe the bones of the forearm. 25. Tell what you know about the bones of the hand. 26. Name the bones of each part of the lower limbs. 27. Describe the bones of the thigh and leg. 28. Tell what you know about the bones of the foot. 29. How are bones joined together? 30. Describe the different kinds of joints and illustrate.

31. Describe ligaments and explain their uses. 32. Explain the general uses of bones. 33. What happens when bones are broken? 34. Give some hints about the health of bones. 35. What is the effect in general of alcohol upon the growth of bones? 36. How does tobacco injure the growth of bones? 37. Give orally, in order of Review Analysis, p. 42, the bones of the head. 38. Give orally in order the bones of the trunk. 39. Mention the bones of the upper limbs. 40. Give orally the bones of the lower limbs. 41. Write on the blackboard, in tabular form, the names of all the bones of the body, as arranged in Review Analysis, p. 42.

CHAPTER III

THE MUSCLES AND HOW TO USE THEM

64. Muscles as the Organs of Motion. The energy set free in the burning, or oxidation, which is constantly going on in the bodily tissues is the source of the active powers of our bodies.

These active powers are mainly manifested in the form of **motion** or **movement,** either of a part of the body or of the body as a whole.

These total or partial bodily movements are produced by **muscles, — the organs of motion.**

65. Variety of Muscular Action. The lean meat or flesh which forms the rounded, shapely covering for our bony framework is **muscle.** When we eat beefsteak or mutton we are eating muscle. Muscles, of which there are more than four hundred in the body, are also the means by which the body is kept in the erect position and in other positions which call for effort.

The limbs are moved by muscles. Even the motions of the stomach and the action of the heart are caused by muscles. Muscles move the skin. In many animals this action is well marked, as when the horse shakes his hide to get rid of biting flies. Muscles move the bones, the lips, and the eye.

In brief, **all motion in our bodies is dependent upon muscular activity.**

66. Two Great Kinds of Muscles. We shall learn later that all the varied movements of the muscles are carried on under the control of the nervous system. Some of these movements are under the control of our will, while others are managed by the nervous system quite independently of the will. For instance, we know we have it in our power to decide when to move our head, our hands, or our feet. The muscles whose duty it is to move them are under the control of our will. We call these **voluntary** muscles.

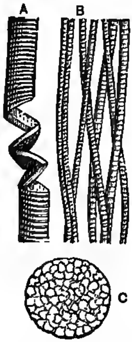

FIG. 34. A Portion of a Striped Muscular Fiber.

Highly magnified.

A, fiber separating into disks; *B*, fibrillæ; *C*, cross-section of a disk.

On the other hand, our will has no control over the muscles of the stomach, the heart, or any of the internal organs. The work of these organs goes on night and day without regard to our will. We call these **involuntary** muscles.

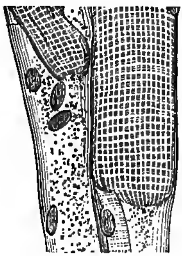

FIG. 35. A Portion of Striped Muscular Fiber, showing Stripes and Nuclei.

Highly magnified.

Experiment 13. *To show the general appearance of the muscles.* Obtain the lower part of a sheep's leg, with most of the lean meat and the hoof left on. One or more of the muscles, with their bundles of fibers, fasciæ, and tendons, are readily made out with a little careful dissection.

Experiment 14. *To show the gross structure of muscle.* Take a small portion of a large muscle, as a strip of lean corned beef. Pick the bundles and fibers apart with fine needles until they are so fine as to be almost invisible to the naked eye. Continue the experiment with the help of a hand magnifying glass or a microscope.

67. The General Build of Voluntary Muscles. The **voluntary muscles**, although they seem to be solid masses of red meat, really consist of separate bundles of flesh held together by a very thin web of connective tissue, not unlike the thinnest of tissue paper. Each bundle of flesh is a muscle with its own set of blood vessels and nerves, and is inclosed in its own sheath of connective tissue.

68. How the Voluntary Muscles look under the Microscope. If the tiniest bit of a voluntary muscle be examined with the microscope, it is found to consist of bundles (**fasciculi**) of separate fibers arranged side by side. Each separate fiber is inclosed in an elastic sheath (**sarcolemma**).

Fig. 36. Blood Vessels in a Piece of Striped Muscle as seen under the Microscope.

Magnified 340 times.

These tiny fibers are seen to be marked crosswise with dark stripes, and to be separated at each stripe into **disks**.

On account of the cross markings on the fibers these muscles are often called **striped** or **striated** muscles (Figs. 34 and 35).

69. The Involuntary Muscles. The **involuntary muscles** consist of ribbon-shaped bands which surround hollow tubes or cavities in the body. They are never attached to bony levers nor are they furnished with tendons, as are the voluntary muscles.

Under the microscope these muscles are found to consist, not of fibers, but of long, spindle-shaped cells, bound together in such a way as to form bands or ribbons. They are often called **unstriated** or **unstriped** muscles.

70. How Muscles contract. Muscles have a peculiar power of their own. This is the power to **contract** throughout their length or to become shorter and thicker.

Contraction is not, however, the natural state of a muscle. After a longer or shorter time it is tired and begins to relax. Even the heart, the hardest working muscle of the body, rests between its beats.

FIG. 37. A Spindle Cell of Involuntary Muscle.

Highly magnified.

In order to contract, a muscle must be stimulated. This stimulus, or that which gives it the power to contract, is a **nervous impulse** which is sent along the nerve fibers from the central nervous system. This stimulus acts upon the muscles and causes them to shorten in length and swell in girth.

71. Why Muscles contract. The purpose of the contraction of muscles is plain. By contracting, muscles become shorter and thicker and the two ends are brought closer together. Now, if one end of a muscle is attached to a fixed point and the other end is fastened to some object which is free to move, the contraction of the muscle will bring the movable body nearer to the fixed point.

Thus, the muscles cause the motion of the parts to which they are attached. This motion in turn gives rise to

locomotion or other movements of the body. In other words, **muscles by their contraction are able to do work.**

The part of a muscle which remains fixed when it contracts is called its **origin.**

The end which is connected with the movable part is its **insertion.**

Experiment 15. *To shew how muscles relax and contract.* This experiment illustrates the contraction of the biceps, and is popularly called "trying your muscle." Lay your left forearm on a table; grasp with the right hand the mass of flesh on the front of the upper arm. Now gradually raise the forearm, keeping the elbow on the table. Note that the muscle thickens as the hand rises.

Reverse the act. Keep the elbow in position, bring the forearm slowly to the table, and the biceps appears to become softer and smaller, — it relaxes.

Experiment 16. Repeat the same experiment with other muscles. With the right hand grasp firmly the extended left forearm. Extend and bend the fingers vigorously. Note the effect on the muscles and tendons of the forearm.

72. How the Muscles work in Harmony. A single muscle rarely or never contracts alone, but always in harmony with a number of other muscles. Even the simplest movement we can make requires the combined action of several muscles to carry it out. If the movement is at all difficult, such as playing on the piano or riding on the bicycle, the different muscles must contract in a certain order and with a certain strength and rapidity.

This harmonious working of the muscles is spoken of as **muscular coördination.** Unless the muscles work in perfect harmony, the complicated movements will be performed in a clumsy and imperfect way.

73. The Function of Tendons. If we bend the leg or arm and grasp the inside bend of the joint with the hand,

FIG. 38. Superficial Muscles of the Body. (Front view.)

we feel the motion of cords just beneath the skin. These are the **tendons**, or sinews, forming the tapering ends of muscles, which are fastened to the bones.

Tendons are white, glistening cords, or straps, which connect the muscles with the bones. They are very strong but flexible. Children often amuse themselves by getting at the market the leg of a fowl or a rabbit, and moving the toes by pulling a white cord in the leg. This cord is a tendon.

FIG. 39. The Tendon of Achilles.

Experiment 17. Tendons may be admirably shown in the leg of a fowl or turkey. Obtain the hoof of a calf or sheep with one end of the tendon of Achilles still attached. Test its strength.

Experiment 18. With the thumb and forefinger of the right hand, grasp firmly the inside bend of the left elbow. Bend and extend the left forearm vigorously. The action of the biceps tendon may be readily studied.

74. How the Muscles are named. Each muscle has its own name given to it from its peculiar shape, size, or from the special work it has to do. Most of these names are Latin words, and are often hard to remember. Thus, some of the muscles which help bend the fingers and the toes are called **flexors**, while those which straighten them are known as **extensors**.

Some muscles have several points of insertion, — for example, the two-headed muscle (**biceps**) and the three-headed (**triceps**). Other muscles are named from some resemblance to figures in geometry, as the **trapezius** and **rhomboid**, or from the direction of their fibers, as **rectus** and **oblique**. Again, we have in the lower limb the tailor's muscle (**sartorius**), and the sole muscle (**soleus**, the sole, a fish).

75. A Few Muscles about the Head. We chew our food for the most part with the help of two strong muscles, called the "chewing muscles" (**masseter**), which move the jaws. They are very large and strong in flesh-eating animals, like the lion and the tiger.

FIG. 40. Tendons on the Back of the Left Hand.

Turn the head suddenly to one side, and the sharp edge of a muscle is plainly seen and felt on each side of the neck: one end is fastened to the skull, the other to the breastbone and the collar bone. This muscle (**sterno-cleido-mastoid**) serves to turn and to brace the head.

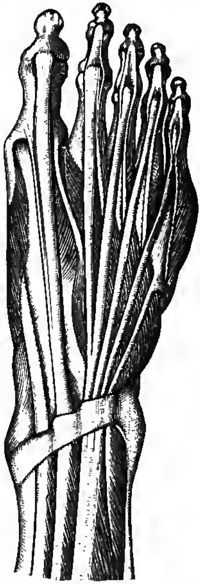

FIG. 41. Tendons on the Top of the Right Foot.

Inside the cheek is a flat muscle, called the "trumpeter's muscle." It is largely developed in glass blowers and in persons who play on wind instruments.

Experiment 19. With the head slightly bent forward, grasp between the fingers and thumb of the right hand the edge of a muscle on the left, just above the collar bone. Raise the head and turn it from left to right, and the action of this important muscle (sterno-cleido-mastoid) is readily seen and felt. In some persons, especially with those who are lean or who have been seriously ill, this long, slender muscle stands out in bold relief.

76. Some Muscles about the Shoulder and Chest. The large muscle on each side of the chest is fan-shaped, and powerfully developed in strong men (**pectoralis major**). It helps draw the arm inward and forward.

The large, thick muscle covering the shoulder is thought to resemble the Greek letter Δ (**delta**). A military officer

FIG. 42. Principal Muscles on the Left Side of the Neck.

wears his epaulet over this muscle. The action of the two-headed muscle (**biceps**) which bends the forearm, and the three-headed (**triceps**) which straightens it, is familiar under the name of "trying your muscle."

A three-sided muscle (**trapezius**) covers the shoulder blade, like a monk's hood, and helps move the shoulder.

77. Some Large Muscles of the Back and Legs. A very broad muscle in the back is the "climbing muscle" (**latissimus dorsi**), which serves to pull the arm backwards.

Three huge muscles make up the greater portion of the fleshy mass in the lower part of the back. They move the thigh backwards and help to keep the body erect. The longest muscle in the body, called the "tailor's muscle" (**sartorius**), runs across the thigh in front. It helps us to cross the legs.

FIG. 43. Some of the Larger Muscles on the Back of the Shoulder and the Arm.

Two strong muscles form the largest part of the calf of the leg.

These muscles are constantly called into use in walking, cycling, standing, dancing, and leaping. They are of great strength, because in raising the heel they have to raise the weight of the body.

The tendons of these two leg muscles unite to form the **tendon of Achilles** (Fig. 39).

PHYSICAL EXERCISE

78. Why we need Physical Exercise. To keep the body in good health, a certain amount of **physical exercise** should be taken every day. The reason for this is plain. As we have learned, the tissues contain a countless number of little cells, to which the ever-changing blood, in its ceaseless current, brings oxygen and nutriment. The tissues

take what is specially suited to their wants, and return the waste matter.

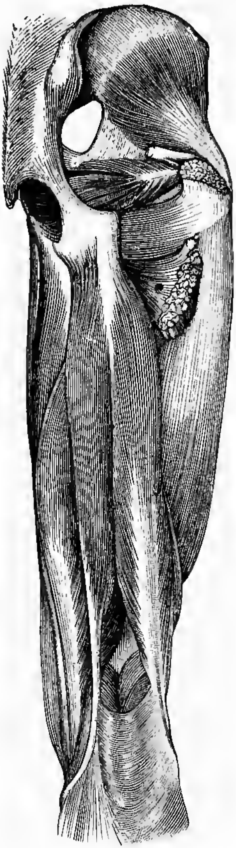

FIG. 44. Some of the Larger Muscles on the Back of the Thigh.

Powerful tendons at the hip and on the back of the knee are well shown.

Now, in every tissue, especially in the muscular tissue, this process is hastened by action. Exercise causes more frequent changes in the tissues and hence an increased flow of blood. Muscular activity is, then, the chief agent in bringing about these wholesome tissue changes.

79. Effects of Exercise on the Muscles. Muscles increase in size and strength according to the use made of them. The blacksmith uses vigorously the muscles of his arms and chest day after day, hence they become well developed.

Let a muscle be kept idle for some time and it loses in bulk and vigor. We read of certain people in India, who, as an act of worship, keep one arm raised above the head for many weeks. The muscles shrivel and the arm becomes useless.

If a leg is broken and kept in splints for several weeks, the muscles become feeble and wasted. It is only after a great deal of exercise that the long-idle limb regains its former size and vigor.

80. Effect of Exercise on Various Organs. Many other organs besides

the voluntary muscles become more vigorous through exercise. When we exercise the heart beats more vigorously and carries more blood to the tissues. Exercise causes the lungs to draw in an extra amount of fresh air and to get rid of more impure air.

Again, exercise stimulates the organs of digestion, giving a good appetite by creating a demand for food. Hence the skin, the lungs, the kidneys, and the intestines have to do more work to get rid of the increased waste products.

81. Amount of Physical Exercise. The amount of exercise which is necessary to keep the body in the best condition is a most important and practical question. Too much exercise, as well as too little, is a fruitful cause of ill health.

Exercise beyond the point of fatigue only does harm, while judicious exercise with suitable rest is of real benefit.

It may be laid down as a safe rule that a person of average height and weight, engaged in study or any other indoor or inactive business, should have an amount of exercise equivalent to

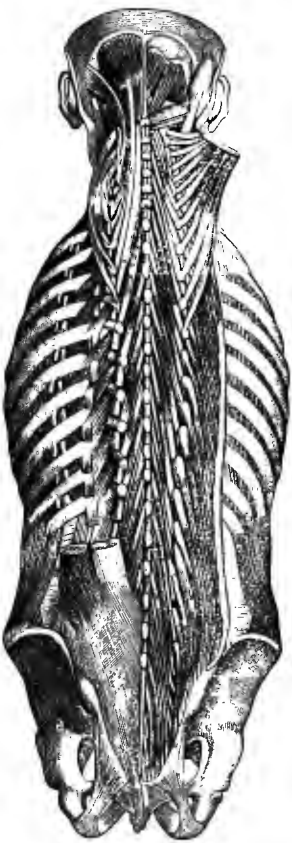

FIG. 45. One of the Deep Layers of Muscles of the Neck and the Back.

a daily walk of five miles along a level road. Growing children, as a rule, take more exercise than this; while most men in the prime of life working indoors take nothing like this amount, and many women take even less. If one's daily work is active and outdoor, no additional exercise is really necessary. The age is an important matter. A young man or young woman may easily and safely take an amount of exercise that might do much harm to a person in advanced life.

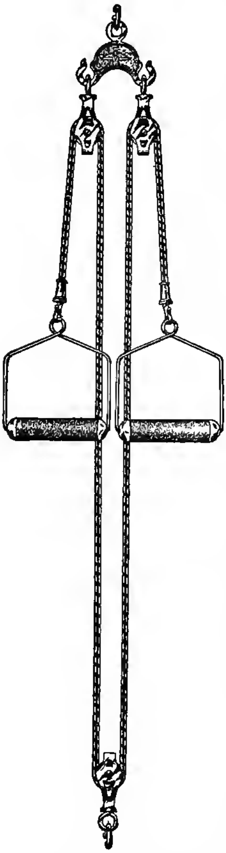

FIG. 46. A Whitely Exerciser.

Exercise may be varied in many ways, — the more ways the better. But for the most part it should be taken in the open air.

82. Time for Exercise. The best time to take exercise is about two hours after a meal. It is not well to do hard work or take severe exercise before breakfast. Those who go to work or study before this meal should first eat half a slice of bread, or a biscuit, or even drink a glass of milk, — just enough to "stay the stomach," and thus save the feeling of faintness or "sinking."

Just after a full meal the stomach is busily doing its duty. Exercise at this time is apt to retard its action and result sooner or later in dyspepsia. Children should not take physical exercise when they are overtired or hungry.

The evening is not the best time for exercise because the body is tired after the labor of the day. Ordinary work or moderate exercise, as walking, is beneficial at almost any time, except, perhaps, just after a full meal.

83. Different Kinds of Exercise. The kind of exercise needed depends very much upon one's daily occupation. Persons who sit at desks, stand at counters, or work in close rooms, as clerks, teachers, tailors, printers, etc., are prone to diseases often traced to lack of bodily exercise and to foul air.

FIG. 47. School Girl practicing on a Health Exerciser.

All well persons should do some work or take some exercise every day. To get and to keep vigorous health it is not at all necessary to increase the size of the muscles very much or to do great feats of strength.

84. Walking. Walking is perhaps the most convenient and useful of all the exercises for most people. It takes us into the open air and bright sunlight. It puts new vigor into the work of many important muscles of the chest, the abdomen, and the limbs. With a brisk walk every day while in good health, and taking care to keep warm and dry, no one need suffer from lack of proper exercise.

Running, leaping, climbing, and other vigorous sports are well enough if they are not kept up so long as to cause extreme fatigue.

85. More Vigorous Exercises. Vigorous sports, such as baseball and football, are severe exercises. Rowing is admirably suited to most persons of either sex. Horseback and bicycle riding,[1] swimming, tennis, golf, and skating are important helps toward bodily vigor, and develop a certain amount of skill and adroitness of action.

Certain sports also tend to beget self-reliance, coolness in danger, and a certain dignity and grace of person. There is hardly any one kind of exercise which, taken alone, is able to give even a fair development of all the muscles.

86. Gymnastic Exercises. Light gymnastic exercises are a convenient means of developing muscles which are not used in ordinary work and games.

Growing children should be trained every day at home or in school in the use of light wooden dumb-bells, light clubs, or wands. A daily exercise of ten minutes will do

[1] It is not the fashion at this time to use the bicycle so much for exercise as in former years. Such riding, however, tends to promote good health fully as much as any other form of exercise. A bicycle is always ready. A half-hour's spin can be taken every day, when the weather permits, by even the busiest. A ride of ten or even twenty miles a day, on a fairly level road, at a speed of not more than nine or ten miles an hour, is for most persons excellent exercise.

It is especially as a heart and lung exercise that wheeling is beneficial. The muscular exercise involved in moderate and not too rapid cycling is just sufficient to induce stronger contractions of the heart, and this results in increased activity of the circulation; for more blood passes through the lungs in a given time, and so it is aërated more efficiently. At the same time the heart muscle is strengthened by its increased action. In addition, the rapid movement in the open air and the exhilaration of the exercise increase the rapidity and depth of the inspirations, the lungs are expanded more fully, and air is forced into the smaller tubes and air chambers.

much to develop feeble and narrow chests, to check the tendency to curvature of the spine and round shoulders so common with school children, and to give muscular strength and vigor to all parts of the body.

87. Physical Exercises in Schools. Pupils should have some sort of physical exercises provided for them in the

FIG. 48. Pupils in the Schoolroom of a Lower Grammar Grade taking an Exercise in Light Gymnastics.

schools, which should be made a part of the regular course. Impure air, lack of proper ventilation, faulty positions long continued, and other conditions unfavorable to health, demand a rest for overtired muscles and overtaxed nerves. This is especially true in large towns and cities, where there is often little opportunity for outdoor games.

88. Beneficial Effects of Physical Exercises in Schools. Physical exercises in schools, if properly done, increase the breathing power and quicken the action of the heart. They fill the arteries with pure blood, and distribute it with increased energy to all the tissues and organs of the body, stimulating them to renewed activity. They brace up the whole system and at the same time furnish what is very important, — a pleasant recreation.

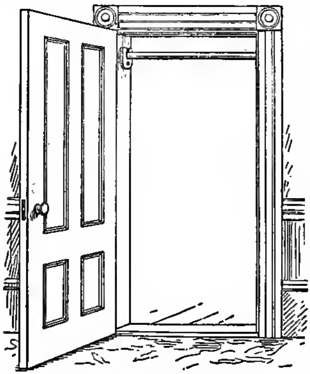

FIG. 49. A Simple and Inexpensive Home Apparatus for Exercise on the Horizontal Bar.

NOTE. — There are several excellent and inexpensive "health exercisers" now on the market. Handbooks or manuals which explain their use and also furnish a series of physical exercises accompany them. Booksellers can usually furnish catalogues of books, and price lists of the various kinds of apparatus for physical culture.

The book above all others which should be read and reread by every one who is interested in physical education is Blackie's *How to Get Strong and How to Stay So*. It is full of stimulating, wholesome advice and practical suggestions to those who wish to practice health exercises at home or at school.

89. The General Effect of Alcohol on the Muscles. We have learned that the nerves act upon the muscles and make them contract or relax. Now, if we drink a certain amount of alcoholic liquor, our muscles are acted upon in a peculiar way. The nerve force that controls the muscles is weakened, and they soon show a lack of control.

The delicate movements which require the long training of certain muscles, as in doing fine work and gymnastic

feats, cannot be made. A person may know the right way of making each movement, and may succeed, after a fashion,

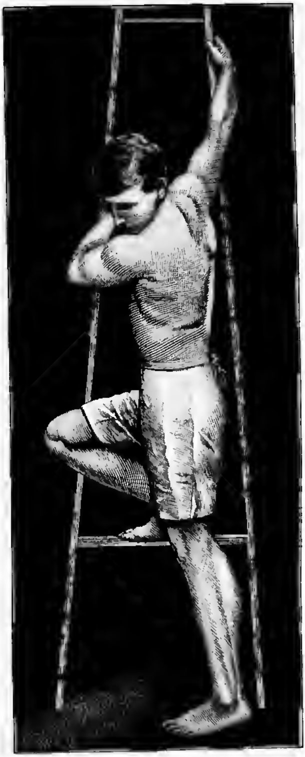

FIG. 50. Showing Some of the Larger Muscles on the Left Side and Back of the Body that are brought into Play in descending a Ladder.

From a photograph of the living model.

FIG. 51. Diagrammatic View showing Some of the Larger Muscles on the Left Side and Back of the Body as exhibited in Fig. 50.

Based upon a photograph of the living model.

in doing it clumsily; but the trained muscles are no longer wholly under the control of the will. If enough alcohol is taken, all control of the voluntary muscles may be lost, and deep breathing may be the only sign of life.

90. Effect of Alcoholic Liquor upon Speech. This same lack of control is shown in the act of speech. Each and every word we utter requires special movements of the muscles of the tongue, palate, and throat, all acting in harmony. After drinking alcoholic liquor there is less control of the muscles: the reins are slackened, so to speak; words may be left out, cut short, or misplaced. According to the stage of intoxication, the words are clipped, stammered, "mouthed," or "thick," from loss of control of the muscles of the tongue and throat.

The muscles that move the eyes do not act in harmony; hence the drunken man "sees double."

The degree of this loss of muscular control and the rapidity with which it is produced vary with the individual, with the amount, with the kind of drink, with the rate at which it is drunk, and with many other circumstances.

91. Effect of Alcohol on Muscular Strength. Many people honestly suppose that alcohol gives them strength for their work and rests them when they are tired. In both cases they are mistaken. Instead of adding to strength or diminishing weariness, alcohol deadens the nerves and impairs the judgment. For it is shown that when the strength is tested with a health lift or other means, the habitual user of strong drink is found to be weaker after taking alcoholic liquor than before. After the effect of the alcohol has passed off the feeling of weariness is more intense than before, showing that the alcohol did not remove it but only concealed it.

92. Effect of repeating the Amount of Alcohol. A repetition of the alcoholic drink may again create insensibility to the fatigued feeling, and the muscles may again obey the will, but only for a briefer time than before. In this way the man who could have put forth just so much strength in an emergency, and could have held out longer, accomplishes less work, abuses his muscles, and deludes his mind by resorting to alcoholic drinks. He has also the injurious effects of the alcohol on other parts of his body to contend with afterward.

93. How Alcohol impairs the Structure of Muscular Tissue. Medical men tell us that changes in the muscles, called "fatty degeneration," are, in many cases, the direct result of the long-continued use of large doses of alcohol and when once the process of degeneration has been set up even small doses appear to exert further injurious effects upon the diseased muscular tissues.[1]

94. Effect of Tobacco on the Muscles. Tobacco tends to weaken the nerve stimulus which controls muscular

[1] It has been demonstrated on all sides, at the forge, in the workshop, in the field, on the march, in the arctic region and in the torrid zone, in physical and in intellectual labor, that the spirit drinker fails to cope with the temperate man. — WILLARD PARKER, M.D., for many years Professor of Surgery in the New York College of Physicians and Surgeons.

All medical authorities are agreed that in periods of prolonged physical labor, more and better work will be done by men who slake their thirst on non-intoxicating drinks than by those who drink large quantities of beer. — *British Medical Journal.*

The disadvantageous effect of alcohol on persons performing muscular work is well known, and the evidence is overwhelming that alcohol in small amounts has a most deleterious effect on voluntary muscular work. — VICTOR HORSLEY, in *Lees and Rapier Memorial Lecture.*

No amount of alcohol, however given, can increase the amount of work done in that same period without giving rise to very serious disturbances in other parts of the body; indeed, the amount of work done is never really increased. — G. SIMS WOODHEAD, M.D.

movement. The result is well illustrated in the unsteady hand of the inveterate cigarette smoker when he attempts to draw a straight line or do other nice work which requires precision of touch.

95. Alcohol and the Operations of Armies. The armies of the great nations are often called upon to undertake at short notice long campaigns in almost every climate of the world. A modern army is built up and handled upon a strictly scientific plan.

Many experiments have been made upon large armies to test the value of a daily ration of alcoholic liquor to men exposed to the dangers of tropical climates and forced to endure every variety of hardship. The results of these experiments upon the British armies during the recent arduous Boer campaigns in South Africa show that the soldiers could endure longer marches with no strong drink than when it was allowed them as a part of their daily fare. England's ablest generals, who handle their armies upon a scientific basis, have strictly forbidden the supply of alcoholic liquor to any troops under their command.[1]

Experiments go to show that while the men were able to do an increased amount of work for a very short time

[1] We learn that they took this step on two grounds. First, on the ground that from long experience they were convinced that the physical condition of the troops would, under these conditions, be enormously improved, and the men would have much greater staying power, while their dash, determination, and steadiness would also be increased. The second ground appears to have been that the mental and moral stamina of the troops would be preserved in a far greater degree than could possibly be the case if alcohol were served out. The result has been that the health, spirits, and conduct of the troops have been the admiration of all those who have had dealings with them, and this experiment on a large scale has been an unqualified success. — G. SIMS WOODHEAD, M.D.

under the influence of alcohol, they did not bear well sustained labor or exposure. The men of the various regiments that were served with liquor began their marching well, but after a short time it was found that they lagged

FIG. 52. Showing Some of the Muscles of the Body that are brought into Play in Punting.

From a photograph of the living model.

FIG. 53. Diagrammatic View of the Larger Muscles of the Back and Legs as shown in Fig. 52.

Based upon a photograph of the living model.

and were surpassed at the end of the day's march by those soldiers who had not been served with a daily dram of strong drink.

96. Alcoholic Liquors in the Navy. The modern battle ship with its improved machinery and equipment and its large quota of men is entirely unlike the wooden men of war

of a generation ago. Naval experts are making a scientific study of every detail which may insure the best results. Experiments show that in skill and accuracy of movement, with power to endure, the man behind the gun who has taken no alcohol has an advantage over one who has.

On England's battle ships supplies of oatmeal and water placed in different parts of the ship take the place of grog when the fight is on. A few years ago every English sailor had his double ration of rum during battle to "fortify" him for his work.

For these many years no daily rations of alcoholic liquor of any kind have been served to the men on board of American men of war.

During the recent war with Spain no better work was ever done than by our gunners who fought at Manila and Santiago. And yet the accuracy of the firing of the great guns in these two battles was accomplished by men who were served freely with oatmeal and water instead of the old-fashioned double ration of grog. A cool, clear head and a steady hand are necessary for accurate firing. A modern naval commander cannot afford to take chances with gunners who lack absolute control over themselves through indulgence in rations of strong liquor.

97. Effect of Alcohol and Tobacco on Physical Development. The main object of physical exercise is to keep our bodies in such a condition that the average amount of working power can be utilized at any time without harm to the bodily health. To keep up this high standard of physical power and endurance we must observe what have been proved to be the essentials to health.

One essential rule for securing and keeping perfect health is never to drink alcoholic liquors or to use tobacco.

Strong drink and tobacco will put to naught the most elaborate and costly system of physical training. Men who train athletes, baseball and football players, oarsmen, and all others who take part in severe physical contests, understand this, and rigidly forbid their men to indulge in alcoholic drinks or even to smoke or to chew tobacco.

Experience has proved beyond all doubt that strong drink is a positive injury, either when men are in training for or undergoing contests demanding long-continued physical endurance. No smoker who has ever trained severely for a race or a game needs to be told that smoking reduces the tone of his system; he knows it.

The same law holds good in the ordinary physical exercises of everyday life. Alcohol and tobacco act as poisons to the nervous tissue which controls the muscles, and thus lessen the amount of muscular power and endurance.

The demands of modern life call for a sound body. He who indulges in alcoholic drinks or tobacco runs a risk of having a weak body instead of a sound one.[1]

[1] Total abstinence from alcohol and tobacco is required from all competitors while in training for athletic games and races. A man who, after election as a member of his college crew, should be found secretly drinking beer or smoking would be hissed out of college. — H. NEWELL MARTIN, M.D.

The tobacco habit is injurious to health, to scholarship, and to character. It weakens the will, diminishes the power of application, and lowers the tone of thought and feeling. Excessive smokers are uniformly poor scholars. — W. D. HYDE, D.D., President of Bowdoin College.

No railroad, electric-car, steamboat, telegraph, or telephone company, no manufacturing concern or printing house will to-day, if they can help it, employ a man who is a regular drinker, to say nothing of a drunkard. Safety first forced this action on certain corporations and others have followed out of economy, and it will not be long before no concern will be able to afford to employ the man who drinks. — HENRY GRAFTON CHAPMAN, in *The World's Work.*

QUESTIONS ON THE TEXT

1. What is the source of the active powers of the body? 2. In general, how are these active powers manifested? 3. How are the bodily movements produced? 4. What is muscle? Illustrate. 5. Give a few illustrations of the work of muscles. 6. Upon what is all motion in our bodies dependent? 7. Name the two great kinds of muscles. 8. How do these two kinds of muscles differ from each other? 9. What is the general build of the voluntary muscles? 10. How does voluntary muscle look under the microscope?

11. Describe the involuntary muscles and the appearance of their tissues under the microscope. 12. What is meant by muscular contraction? 13. What is the object of contraction? 14. What is meant by muscular coördination? 15. What are tendons? Illustrate. 16. In a general way, how are muscles named? 17. What muscles of the head can you mention? of the shoulder and the chest? of the back and the legs? 18. Why do we need physical exercise? 19. In general, what is the effect of exercise on the muscles? Illustrate. 20. What is the effect of exercise on various important organs?

21. What can you say about the amount of physical exercise needed? 22. What is the best time for exercise? 23. Upon what does the kind of exercise depend? 24. What can you say about walking as an exercise? about the more vigorous exercises? 25. What is the object of gymnastic exercises? 26. What good results may be due to such exercises? 27. Why do we need physical exercises in school? 28. What are some of the beneficial results of such exercises? 29. What is the general effect of alcohol on the muscles? 30. What is the effect of alcoholic liquor upon speech?

31. Describe the effect of alcohol upon muscular strength. 32. What is the effect of taking alcohol repeatedly? 33. Explain the effect of alcohol upon the structure of muscular tissue. 34. What is the effect of tobacco on the muscles? 35. Tell what you can of the effect of alcohol upon the operations of armies. 36. Explain and illustrate the effect of alcohol and tobacco on physical development.

CHAPTER IV

FOOD AND DRINK

98. Why we must have Food. In a general way, the body is often compared to a steam engine in good running order. Our bodies, like the locomotive, move about, and are warm, because a slow fire is always burning in them. This fire, like that of the engine, needs fresh fuel from time to time. Food is to our bodies what coal and wood are to the engine.

Without fuel and air the fire in the engine will go out. So it is with the fire that is slowly burning in the body. Without food and air this bodily fire would die out, and we should soon perish. When coal or wood is burned smoke and ashes are formed. When food is burned in the body it forms waste matter, which is got rid of as speedily as possible.

99. How the Waste is made Good by the Food we eat. Everybody knows that a steam engine wears out and needs repair from time to time. So it is with the body. Every beat of the heart, every contraction of a muscle, and even our very thoughts, lead to waste. This tissue change is so complete that not a particle of our present bodies will be ours a short time hence.

Something must be taken into the body to make up for this continued loss of substance. The new material thus used for restoring the waste tissues is the food we eat. If

but little or no food is taken, or if it is not of the right sort, the body slowly loses in weight. If we try to do without food, we grow chilly, feeble, faint, and, after a time, too weak to move.

THE CLASSIFICATION OF FOODS

100. Four Great Classes of Food. For convenience we may divide food into four great classes, to which the name **food stuffs**, or **alimentary principles**, has been given.[1]

I. **Proteids**, or **nitrogenous foods**
II. **Starches and sugars**, or **carbohydrates**
III. **Fats and oils**
IV. **Inorganic**, or **mineral foods**

101. Proteids or Nitrogenous Foods. The **proteids**, frequently spoken of as **nitrogenous** foods, contain all the materials needed to build up and repair the tissues. They contain nitrogen, carbon, oxygen, and hydrogen, — which form the four essential elements of all food.

The type of this class of foods is egg albumin, familiar as the white of an egg. Lean meat, the cheesy part or curd of milk, peas, and beans are rich in proteids. Wheat, barley, oats, and Indian corn also contain them.

The proteids are essential food stuffs, as they are necessary to life. Without them the tissues of the body would gradually waste away. They supply the material from

[1] To this classification may be added what are called **albuminoids**, a group of bodies resembling proteids, but having in some respects a different nutritive value. Gelatin, such as is found in soups or table gelatin, is a familiar example of the albuminoids. They are not found to any important extent in our raw foods.

which new tissue is built up or old tissue is repaired. The burning up or oxidation of the proteids may give rise to heat.

Experiment 20. *To test for proteid with the white of egg.* As a type of a group of proteids let us take the white of an egg, or egg albumin. Place a few drops of the raw white of egg in a test tube. Dilute it with a tablespoonful of water. Heat it over a flame. The mixture will soon begin to turn white, and become thicker, or, in other words, to coagulate.

Experiment 21. *To show grain albumin or gluten.* Take a small mass of dough made of wheat flour; tie it in a piece of cotton cloth and knead it under water until all the starch is washed out. The sticky, stringy mass remaining on the cloth is gluten, made up of albumin, some of the ash, and fats.

Experiment 22. *To show milk albumin or casein.* Heat a little sweet milk in a test tube or basin. It will not coagulate or curdle. Add a few drops of vinegar and gently stir. The milk curdles and separates into a solid curd (casein, the chief proteid of milk and fat) and a yellowish fluid (the whey).

102. Starches and Sugars. The **starches** and **sugars**, also called **carbohydrates**, contain carbon, hydrogen, and oxygen, but no nitrogen. This class of foods forms a large part of all those plants which are generally used as articles of diet.

The starches stand first in importance among the various vegetable foods. Wheat, barley, oats, rye, rice, maize, tapioca, arrowroot, sago, potatoes, etc., are rich in starch.

The sugars are widely distributed substances and include cane, grape, malt, maple, and milk sugars. Honey and molasses are sugar foods.

Cellulose is a carbohydrate that cannot be digested. Of it the bark and the fibers of fruit, cereals, and vegetables are composed.

The carbohydrates are burnt up in the body, and set free a considerable amount of energy. The energy called for in muscular work and that which is transformed into bodily heat come largely from their oxidation.

Experiment 23. *To test for starch.* The test for starch is a very weak solution of iodine, the addition of which to starch will result in a blue color. Pour a tablespoonful of the starchy water obtained from Experiment 21 into a test tube and boil. The starch dissolves and the solution becomes translucent. If a drop or two of very weak solution of iodine be added to the cold starch solution, a blue color will result.[1]

Experiment 24. Secure a specimen of the various kinds of flour and meal, peas, beans, farina, sago, cornstarch, rice, and tapioca. Boil a small quantity of each in a test tube for some minutes. Put a bit of each thus cooked on a white plate and test for starch by adding two or three drops of very weak solution of iodine. Note the various changes of color, — blue, greenish, orange, or yellowish.

Experiment 25. *To test for sugar.* The test for sugar is Fehling's solution (easily obtained of the druggist in the form of solution or in tablets). The little white grains found in raisins are grape sugar or glucose. Milk sugar is readily bought of the druggist. Dissolve one quarter of a teaspoonful of grape or milk sugar in a test tube one quarter full of water. Add an equal amount of Fehling's solution and bring the mixture to a boil. Note that an orange or brick-red precipitate settles to the bottom of the tube.[2]

103. Fats and Oils. The chief **fats** and **oils** used as food are those of meat, eggs, butter, and milk, also the various

[1] The tincture of iodine cannot be diluted with water, but it can be diluted with a saturated solution of potassium iodide. A few crystals of iodine may be dissolved in a saturated solution of potassium iodide to make an amber-colored or pale brown solution.

[2] Fehling's solution does not keep well. Make a fresh solution shortly before it is to be used. Before using, test it by boiling a small quantity in a clean test tube. If it does not keep its clean blue color, a fresh supply should be prepared before making any tests.

vegetable oils. Most of the breadstuffs contain more or less fat. The fats and oils are rich in carbon and hydrogen but contain little oxygen. They are more valuable than the starches and sugars as sources of energy, but the latter are more easily digested.

104. Mineral Salts. Besides the food stuffs which are obtained from the animal and vegetable kingdoms, our bodies must have a certain amount of **mineral matter**.

The principal mineral foods are water, salt, iron, lime, magnesia, phosphorus, and potash, which are present both in vegetable foods and in meat. Except water and common salt, the mineral substances usually enter the body only in combination with other food stuffs.

Some of the salts of food play an important part in directing the chemical changes that take place in the tissues of the body. Others give hardness to the bones and the teeth.

Experiment 26. *To test cereals for fat.* Mix an even teaspoonful of Indian meal, oatmeal, or rye meal with an equal volume of benzine. As its *vapor* is highly inflammable, the greatest caution must be exercised not to handle it near a flame or a hot stove. Stir carefully and filter the mixture after it has stood for fifteen minutes to get rid of the ether odor. Evaporate some of the filtrate on a watch glass. A greasy residue is left, which may be shown by rubbing it on a piece of tissue or rice paper.

Experiment 27. Evaporate a small quantity of milk to dryness in an open dish. After the dry residue is obtained, continue to apply heat; observe that it chars and gives off pungent gases. Raise the temperature until it is red hot, then allow the dish to cool; a fine white ash will be left behind. This represents the *mineral* matter of the milk, which does not burn.

The preceding experiment shows that a great part of milk is made up of water. The residue is the solid substance. The loss of weight is due chiefly to the loss of water.

105. Condiments or Appetizers. Certain substances are used by man to give flavor to tasteless foods, thus producing an increased flow of the digestive juices and a better digestion. These substances, such as pepper, nutmeg, cloves, mustard, ginger, and similar appetizers, are called **condiments.** Such stimulating foods may be used in safety only in moderation.

IMPORTANT ARTICLES OF DIET

106. Different Kinds of Bread. There is no single food in the world which meets so many necessary wants of the body as bread, "the staff of life." It is made from the flour of wheat, oats, rye, Indian corn, and other cereals.

Wheat flour gives us starch, sugar, and gluten, — a form of proteid food. Hence wheat bread contains nearly everything to support life except fat. When we eat bread and butter we have a nearly perfect food.

Corn meal is rich in nitrogen and has much oily matter. It is highly nutritious and a cheap article of food. Oatmeal is richer than flour in nitrogen and fat, and is therefore more nutritious. Rice, though rich in starch, is one of the least nutritious of all the cereals.

107. Vegetables and Fruits. The common or white potato is a most important article of diet. Although it is more than two thirds water and has little nutriment, yet it is easily digested. Sweet potatoes are rich in starch and sugar.

Ripe fruits, such as apples, pears, peaches, strawberries, grapes, bananas, melons, oranges, etc., though not of much nutritive value, are a useful addition to our regular diet. They are prized for their agreeable flavor and for the salts which they contain.

Sugar and molasses are both largely used in cooking. Their nutritive value is about the same as that of starch. Peas and beans contain more nitrogen than any of the cereals and are as rich in carbon.

108. Garden Vegetables. Various kinds of fresh and juicy garden vegetables, as celery, lettuce, cucumbers, radishes, and tomatoes, are widely used for their agreeable flavor. They give a pleasant variety and relish to other articles of food. They furnish little nutriment but are rich in salts.

109. Milk and Eggs. Milk is the food of all others which affords nourishment in the simplest and most convenient form. This ideal food contains a large quantity of water, casein, sugar, and fat.

Eggs have a large amount of nutriment in a small bulk. They are usually easily digested.

110. Meats. Meats, for the most part, consist of the muscles of the various animals. The most common are beef, mutton, lamb, veal, and pork. They are important articles of diet and as a whole are easily digested, except, perhaps, veal and pork. Fish is at once a cheap and a nourishing food. Poultry is a useful, light article of food, easy to digest, and providing a great deal of nourishment.

111. Mineral Foods. There is about a half pound of common salt in the body, but we are continually losing it. Tears, we know, contain salt, and it is also found in the sweat. Many people think they do not eat any common salt because they do not take it by itself; but they forget that many of the foods they eat, such as bread and meat, contain a little of it.

The salts of potash are chiefly found in the vegetables we eat, especially lettuce. These salts are needed in the blood. The salts of lime make the bones hard and strong.

An iron salt is found in very small quantities in many of the foods we eat. It helps make good blood. Sulphur is obtained from the yolk of eggs.

112. Water. Drink is of just as much importance as solid food. Every one knows what happens to plants when they are deprived of water. They first droop and then soon afterwards wither and die. So also it is with all animals. If they are deprived of their drink, they also droop and at last die.

Water is the agent which has been provided by nature to wash the food through the living tissues. Wild animals, as well as domestic, take no other drink but water. Pure water is the only drink that is absolutely essential for good health. Thousands of human beings, following the example of the lower animals, drink nothing but water, but yet toil long and hard and keep well and strong.

To be suitable for drinking, water should be clear, without color, with little or no taste or smell, and free from any great amount of animal or vegetable matter.[1]

[1] There is a definite group of diseases which are especially liable to be spread by means of bacteria in drinking water. Among these are such diseases as typhoid fever and cholera.

The appearance of the water is by no means conclusive, for it may be beautifully clear and palatable, yet contain myriads of deadly bacteria; or it may be muddy and of a disagreeable odor and taste, and yet contain nothing of a really harmful nature. The only way by which absolute certainty can be had lies in a chemical and bacteriological analysis, repeated at regular intervals.

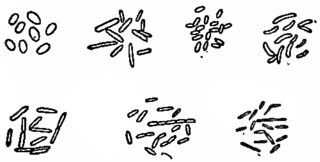

FIG. 54. A Group of the More Common Bacteria found in Water.

No water at our command upon the surface of the earth is absolutely free from bacteria. Spring water is the purest, and water from deep artesian wells is about equally pure. Water from lakes and reservoirs is next

113. The Use of Water in the Body. It is plain that if we take a quart or more of water every day, nearly an equal amount must be thrown out from the body. Some of it steams away with the breath. More of it passes through the pores of the skin as perspiration, and still more is drained away through the kidneys. Thus, water drains off a great deal of waste matter from the body. A great amount must be supplied, especially in hot weather, to make good this loss.

This topic is more fully treated in Chapter IX.

114. Drinking in Hot Weather. One of the most common of all drinks used in this country is ice water. The temptation to drink freely of it in hot weather is rarely resisted. It should be sipped slowly and only a small amount taken at a time.

It is a dangerous thing to drink ice water in great gulps when overheated. The proper way is to rinse the mouth and take slowly a few swallows. It is always to be remembered that very little cold water is really needed to quench thirst and refresh the heated body.[1]

115. Refreshing Drinks. The greater portion of every drink is water; but, in various ways, other substances are mixed with the water to give it a pleasant taste.

Many kinds of refreshing drinks, made up for the most part of flavored water slightly charged with carbonic acid

in purity, and water derived directly from flowing streams and rivers is most likely to contain these organisms in greatest numbers. The most dangerous water for drinking purposes is that of rivers which have been contaminated in any way by sewage material, a condition of things true of the water used in some cities. — H. W. CONN'S *Bacteria, Yeasts, and Molds.*

[1] When overheated, and before drinking cold water, it is always prudent to pour water slowly over the inside of each wrist (over the radial artery), or allow it to run from the faucet. This helps greatly to cool and refresh the body and to lessen the amount of water needed to quench thirst.

gas, are widely used. They are known by a great variety of names, as ginger ale, soda water, and the like. When taken in moderation they are harmless. Tea, coffee, and chocolate are the more common artificial drinks.

116. The Effect of drinking Tea and Coffee. Tea and coffee have little or no value as foods. Some persons cannot drink even a single cup of coffee or tea without feeling worse for it: headache, indigestion, heartburn, wakefulness at night, and constipation are the most common after effects. Strong tea should never be used.

Hard-working women and others, from choice or necessity, too often make their meals of dry toast and several cups of strong tea. Taken in excess, tea may disturb the action of the heart and produce the peculiar beating known as palpitation.

117. Cooking. The art of cooking and serving food well plays an important part in the matter of health, and thus of comfort and happiness. Food is more readily chewed and more easily digested after it is properly cooked. Thus, raw meat is tough and tenacious, but may become tender and palatable after it is cooked. Vegetables and cereals are softened by cooking so that they are more easily acted upon by the digestive fluids. Cooking also brings out flavors in food which stir the appetite and promote the flow of digestive fluids.

Again, cooking kills any minute parasites or germs of disease that may exist in raw food.

Thus, proper cooking not only adds to the comfort and health of daily living but also removes some important causes of disease.

Every young person should be taught to cook properly a few of the more common and important articles of food.

QUESTIONS ON THE TEXT

1. To illustrate work, waste, and repair, how may we compare our bodies to a steam engine? 2. How is the waste made good in the steam engine, and also in our bodies? 3. What are the four great classes of foods? 4. What chemical elements do the proteid foods contain? 5. Why are the proteids necessary to life? 6. In what articles of diet do we find proteids? 7. What chemical elements do the starches and sugars contain? 8. Give some familiar examples of this class of foods. 9. In what articles of diet are the fats and oils found? 10. What is meant by the mineral salts?

11. What is meant by condiments? Illustrate. 12. What can you tell of the importance of bread as an article of diet? 13. Mention some vegetables and fruits that are used for food. 14. What garden vegetables are commonly used for food? 15. Why are milk and eggs important articles of diet? 16. What are some of the principal food materials of animal origin? 17. What is the use of the mineral foods? 18. Why is water important as an article of diet? 19. What properties must water possess in order to be fit for use as an article of diet? 20. What becomes of the water that is taken into the body?

21. What can you say of the use of ice water? 22. Of the use of other refreshing drinks? 23. Explain in a general way the harmful effects of drinking tea and coffee. 24. What are the objects of cooking food? 25. Why is the knowledge of proper cooking necessary to health?

NOTE. — A series of most interesting experiments may be planned by teachers and pupils on the subject of food and drink. It should be our object to understand the few general *principles* which underlie the matter of our daily food. We should aim to become familiar with the principal substances contained in the four great classes of foods. We can do this by exhibiting specimens and by experiment.

The teacher should show specimens of the various cereals, starches, sugars, fats, oils, etc., which have been carefully collected and kept for class use in wide-mouthed bottles bought at the drug store. Small radish or pickle bottles will answer every purpose. Each specimen should be neatly labeled with its exact name.

CHAPTER V

ORIGIN AND NATURE OF FERMENTED DRINKS

118. Healthful Juices from Ripe Fruits. If we are thirsty and we do not wish to drink water, we can relieve our thirst by the juice of ripe fruits, like grapes, oranges, apples, pears, and peaches. These fruit juices are made up largely of water sweetened with sugar which nature prepares in them as the fruit ripens, and each is flavored according to its kind. Such juices, as we use them fresh from the fruit, are refreshing and healthful.

Now, if we crush one of these ripe fruits and pour a little of its juice into a tumbler and let it stand in the air of ordinary temperature, we all know what will happen. It will remain a healthful drink for a few hours only. A scum appears on the surface, bubbles begin to rise, and there is an unpleasant taste to the liquid. In brief, we say that the fruit juice has turned sour or has begun to "work."

119. Decay a Great Law of Nature. All animal and vegetable matter, as we have learned in the Introduction, is made up of various simple substances, — gases, liquids, and solids. Now, it is one of nature's laws that when plant or animal matter ceases to live, the different substances composing it shall be set free for use again in forming new combinations. A living thing, like a plant or animal, dies and is exposed to the contact of air. To the life which has left it, succeeds life under other forms.

When we see meat or vegetables spoiling, bread or cheese molding, fruit rotting, or milk turning sour, we simply see a few of the countless examples of nature's great law of decay. This "working" or souring only represents the first step of the return to the atmosphere and to the soil of all that has lived.

120. Fermentation. The "working," or fermenting, as it is called, of sweet fruit, plant, or other vegetable juices, which takes place very soon after they are pressed out, is another and familiar example of the same wise provision of nature. This last process is not accompanied by foul-smelling odors, as are most of the others, but by a peculiar bubbling of the liquid caused by the escaping gases; hence the name "fermentation," which is taken from a Latin word meaning to boil.

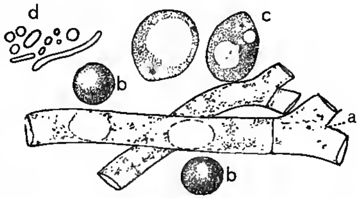

FIG. 55. Showing the Comparative Size of Molds (*a*), Yeast (*b* and *c*), and Bacteria (*d*).

Fermentation in its widest sense includes the changes going on in the putrefying meat, the molding cheese, and the rotting fruit, as well as in the fermenting fruit juice. They are all forms of decomposition that set free the simpler substances composing animal and vegetable matter. For all these one law holds good. It is this:

Fermentation entirely changes the nature of the substance fermented.

121. The Importance of Bacteria in Nature's Work of Decay. What causes all these various processes of decomposition? Are plants and animals so constructed that

when they have served their purpose they fall to pieces of themselves, or from the action of the air, as was once supposed? No; the microscope has revealed to us whole tribes and families of minute living forms known as **yeast, mold,** and **bacteria.** It is the special work of these tiny organisms to change dead animal and vegetable matter into useful substances. In brief, bacteria prepare food for all the rest of the world.

Were it not for these countless myriads of living organisms, the whole surface of the earth would in time be covered with dead trees and other lifeless bodies, and there would be no simple substances left out of which to build up new ones. Were all living forms that are silently at work bringing about these wonderful results destroyed, life upon the earth would be impossible.

122. Living Forms that cause Disease. Among these minute living forms are some that do not even wait for a plant or animal to die before attacking it. Such are the disease germs which are invisible to the naked eye and of an infinite variety of form and manner of life. They lurk in the air we breathe; they occur in the water we drink; they are found in our milk supply, ready to cause sickness if they gain access to our bodies, unless our bodies are strong enough to resist them.

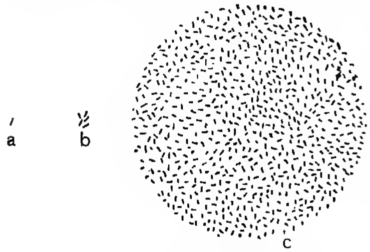

FIG. 56. Showing the Effect of Variations in Temperature on Bacteria Growth.

a, a single bacterium; *b*, its progeny in twenty-four hours at 50°; *c*, its progeny in twenty-four hours at 70°.

123. Bacteria, the Active Agents of Fermentation. The myriads of living creatures that play this part as active agents in the process of fermentation are grouped under the family, or generic, name of **bacteria.**

The words **germs, microbes,** and **microörganisms** are often used with the same meaning as the term "bacteria."

Bacteria are very low forms of plant life, of which there are many varieties. They are roughly divided into groups, according as they are spherical, rodlike, or spiral in shape. It is now known that a large number of species of bacteria exist, but that some forms which have been described are simply stages in the life history of other forms.

It is impossible for us to realize how small these agents of fermentation are. Some of the rod-shaped are from a twelve-thousandth to an eight-thousandth of an inch long, and average about a fifty-thousandth of an inch in diameter. It has been calculated that two hundred and fifty millions of minute organisms would not weigh more than one milligram (Secs. 419–426).

124. Mold. To this great family of bacteria belong certain low forms of plant life familiar as **mold.** This is a low form of fungous growth which is often seen upon decaying wood or old leather. It is this fine, furlike coating which spoils our bread and cheese, causes our sauce to sour, and our fruit to rot.

The work of some kinds of molds may be apparent to the eye, as in the growths that form on old leather and on stale bread and cheese. The work of other kinds of molds goes on unseen, as when acids are formed in stewed fruits. One kind of mold devours our preserves; another turns our bread sour. One kind is nourished at the

expense of our fruits; and another develops itself on paper, on the inside of books, and on their bindings, when they come in contact with a damp wall. Some forms of skin disease, like ringworm, are caused by the growth of this microscopic plant on the skin.

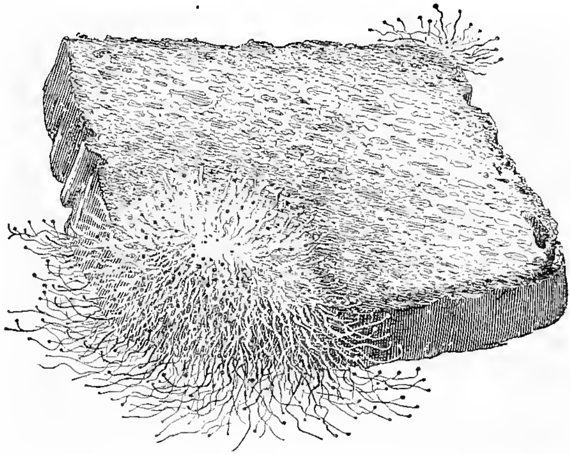

FIG. 57. A Piece of Bread upon which One of the Common Molds, known as *Mucor*, is growing.

125. Different Forms of Fermentation. There is no one particular form of bacteria which can be called the micro-organism of fermentation, but there are a number of fermentations each started by some special form of agent. We must remember, however, that fermentation nearly always consists of a process of breaking down of complex bodies, like sugar, into simpler ones, like alcohol and carbonic acid. Of these fermentations we have the **alcoholic,** by which alcohol is produced; the **acetous**, by which wine absorbs oxygen from the air and becomes vinegar; and the

lactic, which sours milk. The ammonia smell about stables is caused by another form of fermentation due to the breaking down of compounds of nitrogen into ammonia.

When the word "fermentation" is used alone, alcoholic fermentation is usually meant.

126. Alcoholic Fermentation. The fermentation of sweet fruit, plant, or other vegetable juices, composed largely of water containing sugar and flavoring matters, is based upon the growth of a class of microscopic plants commonly known as **yeasts**. This ceaseless action of minute forms of plant life is closely allied to that of bacteria.

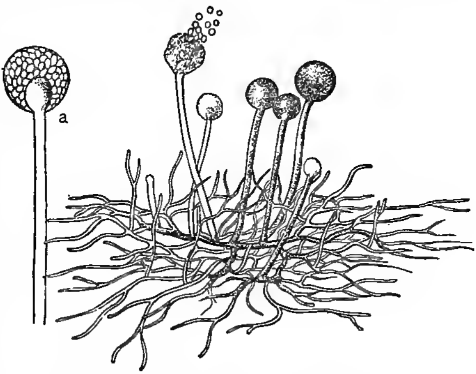

FIG. 58. Showing One of the More Common Molds found on Fruit and Bread.

The tiny stalks grow vertically into the air. The end of each thread swells into a small round knob, from the inside of which hundreds of minute bodies, called *spores*, burst. At *a* is seen a large knob filled with spores.

There are many varieties of the yeast plant which grow on the surfaces and stems of fruit as it is ripening. While the fruit remains whole these germs have no power to invade the juice, and even when the skins are broken the conditions are less favorable for their work than for that of the molds, which are the cause of the rotting of fruit.

But when fruit is crushed and its juice pressed out, these yeast germs are carried into it and cause a breaking up of the sugar and a rearrangement of its elements.

Two new substances are formed out of the material that composed the sugar. One substance is **carbon dioxide,** a gas that passes up and out of the liquid in the form of bubbles.

The other substance is **alcohol,** a liquid and a poison, which remains in the fermenting fluid.

127. Change wrought by Alcoholic Fermentation. It is a law of nature that fermentation changes the character of the substance fermented. Fresh fruit juice that has not begun to ferment is good and wholesome. With the beginning of fermentation its nature begins to change. When all, or nearly all, of the sugar in the fruit juice has been changed to alcohol, the effect of the wine thus resulting upon the person who drinks it will be very different from the effect of the same quantity of fresh fruit juice.

A great variety of plant structures, such as the juice of ripe grapes, pears, apples, and other fruits, and infusions of barley, corn, rye, wheat, and other grains have been used by man in the manufacture of alcoholic beverages. But whatever the substance used, whenever a sweet liquid is made to undergo alcoholic fermentation the result is a liquid containing alcohol and therefore dangerous for use as a beverage.

128. Wine. One of the most common alcoholic beverages is **wine,** made chiefly from the juice of grapes. Home-made wines are often made from the juice of currants, blackberries, tomatoes, and other fruits rich in sugar. As the juice is pressed out of the crushed fruit, the yeast ferments which are in the air as well as on the stems and skins are washed into a vat. Here the ferments bud and multiply rapidly as fermentation begins. In a short time the sugary juice that was sweet and wholesome while in

the fruit has been changed into a liquid containing carbon dioxide which escapes as bubbles of gas into the air, and alcohol which remains in the fluid.[1]

Most wines after fermentation contain from five to fourteen per cent of alcohol. When the fourteen per cent limit is reached these germs are unable to continue their work.

129. The Danger from Wines. - One of the gravest dangers of wine drinking is the power which the alcohol in it has to create a craving for more and stronger alcoholic beverages. We must remember that the power of alcohol to create this craving is not affected by the quantity in any given liquor. It is claimed, for instance, that the light table wines, because they contain a smaller amount of alcohol than others, are less harmful; but the alcohol in even the lightest

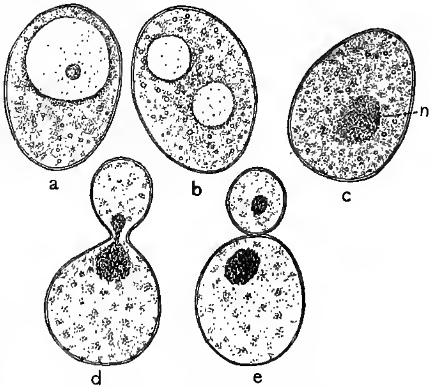

FIG. 59. Showing a Bit of Common Yeast Cake when mixed with Water and examined under the Microscope.

Very highly magnified.

There are large numbers of minute oval bodies, inside of which may commonly be seen one or more smaller bodies known as *vacuoles*, shown in *a* and *b*. *c* shows a nucleus, *n*, inside of the yeast cell; *d* shows a budding cell with the nucleus dividing; *e* shows the cell divided, the new cell containing a bit of the old nucleus.

[1] The ferments have no power of themselves to penetrate the unbroken skin of the healthy fruit. — LOUIS PASTEUR, M.D.

The bloom on the outside of the skin of the grape is full of ferment germs awaiting an opportunity to feed upon, and so to ferment, the sugary juice inside. — W. T. SEDGWICK, PH.D.

table wines has power to create the alcoholic craving. The theory that the use of light wines will prevent the use of stronger drinks, and so diminish drunkenness, is disproved by the history of countries where such wines have come into general use.[1]

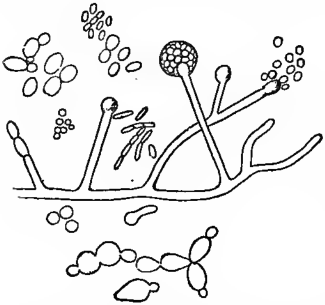

FIG. 60. Organisms found upon the Skin of a Grape and concerned in the Fermentation of Wine.

130. Beer. Certain fermented drinks are called malt liquors. These are beer, ale, and porter, which are made from barley and other grains. By keeping the grain warm and moist until it is sprouted, the starch is turned to sugar. This is done because the yeast germ will not act upon starch. Heat is applied to kill the sprouts, so that the budding plant will not use up the sugar as food. The grain, then called malt, is ground or mashed, and soaked in water. To the sweet liquid thus obtained is added the yeast ferment and hops.

Let us now remember what takes place. The yeast sets up alcoholic fermentation, which changes the sugar of the wort to alcohol and carbon dioxide. The gas escapes in bubbles, producing a froth on the top of the fermenting vat. The alcohol does not escape but remains in the beer, making it a harmful drink.

[1] Not the least of the evils affecting France is her consumption of alcohol. It is known that the honest glass of light wine which used to meet the wants of the ordinary Frenchman is now supplemented with spirit in all forms, and that France is first of all countries in the amount of alcohol which is consumed.—London *Lancet.*

Some kinds of beer contain only a small percentage of alcohol, but these are often taken in such large quantities that the user gets as much alcohol as he would in smaller amounts of stronger drinks.

131. The Food Value of Beer. The drinking of beer does not give strength for work, but on the other hand tends to make people dull, heavy, stupid, and unfit for hard and continued manual or mental labor. Because both beer and bread are often made from the same cereals, the former has been called "liquid bread."

There is a popular saying that "where the brewery is, no bakery is needed." As a matter of fact, chemists tell us that the best beer is more than nine tenths water, from four to five per cent alcohol, and that scarcely two per cent is really food. A healthy grown person would have to drink about two gallons of beer every day to get the same amount of nutriment he would get from a few slices of bread. The harmful effect of drinking this large amount of beer daily would quickly show itself.[1] The food value of a glass or two of beer is of so little importance that it is scarcely worthy of mention.

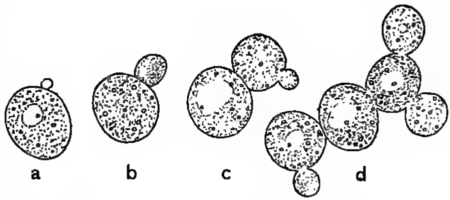

FIG. 61. Growing Yeast Cells, showing Method of budding and forming Groups of Cells.

Each bud appears as a little swelling on the side of the larger cell, as seen in *a* and *b*. In *c* the little bud has grown to be nearly as large as the parent cell. The little buds grow one after another, making irregular shaped groups, as shown in *d*.

[1] The constant use of beer every day gives the system no recuperation, but steadily lowers the vital forces. — *Scientific American.*

Remember, then, from an economical point of view, that beer is in no sense a nutritive food nor in any respect a prudent food.[1]

132. Drinking Beer in Place of Ardent Spirits. It is claimed by some people who realize the evil results of drinking wine, whisky, gin, and brandy, that the drinking of light beers in place of the stronger beverages does much to diminish the use of ardent spirits. This is the question in plain words: Does the drinking of more beer really mean the consumption of less ardent spirits? Not at all. Physicians and students of domestic science who have given much study to the problem most emphatically say, No! They claim that no habitual user of ardent spirits was ever saved from the ill effects of alcoholism by the drinking of beer.[2]

133. The Physiological Effect of Malt Liquors. The habitual beer drinker often looks the picture of health, and perhaps is inclined to boast of the healthfulness of his favorite beverage. The testimony of physicians and life-insurance experts, however, is that the habitual beer drinker is not so physically strong and well nourished as would appear at the first glance. The flesh is not apt to be firm

[1] Let a man drink much beer, enough to make the amount of nourishment in it of value, and the other influences produced by such a quantity will become manifest to such a degree as to cast the factor of nourishment in the background. If he drinks little beer, the food value is not appreciable. — PROFESSOR ROSENTHAL, Erlangen, Germany.

[2] One of the worst features of the poisonous characteristics of alcohol is its power, even in small quantities, to create a craving for itself that becomes irresistible. It is therefore the nature of wine to lead to an increasing use of alcohol. — H. NEWELL MARTIN, M.D.

One can accustom oneself more readily to the drinking of beer than of any other intoxicant, and no other so rapidly destroys the appetite for normal food and nourishment. — GUSTAV VON BUNGE, M.D., Professor of Physiological Chemistry in the University of Basel, Switzerland.

and hard, and the fair outside appearance is mainly due to an unnatural deposit of fat in most of the tissues, especially around the heart and kidneys.

Such a person's physical condition is peculiarly deceptive at first, and is often subject to a sudden collapse at the first touch of disease. The habitual beer drinker is less able to endure an attack of pneumonia, typhoid fever, or heart disease than the total abstainer.

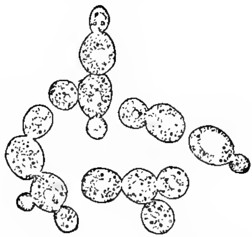

FIG. 62. Yeast Cells, found in the Juice of Apples, which cause the Fermentation of Cider.

The president of a leading life-insurance company once said of this class of drinkers: "It was as if the system had been kept fair outside, while within it was eaten to a shell, and at the first touch of disease there was utter collapse: every fiber was poisoned and weak. And this, in its main features, varying of course in degree, has been my observation of beer drinking everywhere. It is peculiarly deceptive at first, and it is thoroughly destructive at the last."

In brief, the practical experience of the leading life-insurance companies teaches them that the habitual beer drinker is a precarious risk.[1]

134. Cider. When the juice is first pressed from apples everybody knows that it is healthful and refreshing, but

[1] This flooding the stomach and brain with beer, so prevalent among our young students; the habit of drinking between meals, especially during the forenoon; this daily beer drinking, for hours at a stretch, customary among great numbers of the lower and middle classes in Germany; — I regard it all as a national evil, whether considered from the hygienic, economic, or intellectual point of view. — PROFESSOR BINZ, of the University of Bonn, Germany.

it remains so for a few hours only. The ferments which exist in the air and on the skin of the fruit fall into the liquid and begin to play their part. The liquid, or cider, begins to "work," or undergo the process of fermentation. As it was with grape juice, so it is with the juice of the apple. The bubbles of carbon dioxide begin to rise and alcohol is produced.

The amount of alcohol increases a little every day, so that the apple juice, which was harmless while in the apple, soon becomes a source of danger. In a few weeks it may contain almost as much alcohol as we find in beer.

As cider grows older it is said to be growing hard; that is, the amount of alcohol in it is increasing. Hard cider may contain ten per cent of alcohol.

It is well known that the results of intoxication from old cider are as bad as, if not worse than, those resulting from indulgence in ardent spirits. Many a person has acquired the appetite for distilled liquors from drinking hard cider.

135. The Process of Distillation. We all know that when water is heated to the boiling point, or 212° F., it rapidly changes into vapor, known as steam. How often have we watched the steam escaping from the boiling tea-kettle and floating away as vapor to cool off as little drops of water on the cold window glass!

Now, when a fermented liquor is heated, a similar change takes place. The alcohol does not, however, need to be heated nearly so hot as water before it begins to escape as vapor. In other words, the alcohol will be converted into vapor before the water becomes hot enough to form steam.

Thus, when alcohol and water are mixed together, as in fermented liquors, the vaporized alcohol which is driven off

before the water has been heated enough to become vapor, and conducted through a coil of pipes kept cool by running water, is changed back to a liquid form and collected in a receiving vessel.

The result is a new and stronger liquid, known as "spirits" or "ardent (burning) spirits," which is nearly or more than half alcohol. This new liquid is whisky, gin, or brandy, according to the substance or flavors used in the process of manufacture.

This process of separating one liquid from another by vaporizing with heat and condensing the vapor with cold is called **distillation.**

The products of the process are known as **distilled liquors.**

136. Distilled Liquors. Many of the alcoholic liquids are made by distillation. Thus, alcohol itself may be distilled several times until we get a much stronger liquid, clear and colorless like water, with a sharp, sweetish taste and a peculiar odor. Various kinds of alcohol are distilled from wood, from wine and beer, and from whisky and fermenting potatoes and tomatoes. These different forms of alcohol vary in composition, but they are alike in one essential property, — they are all **narcotic poisons.**

The more common distilled liquors used as beverages are whisky, brandy, rum, and gin. Rum is distilled from the fermented molasses of sugar cane; brandy from wine; whisky from fermented potatoes and corn; and gin from the cereals flavored with juniper berries. These distilled liquors contain from forty to fifty per cent of alcohol, the rest being water flavored with various aromatics.

137. The Action of Certain Poisons. A poison is a substance whose nature it is, when absorbed into the blood,

either to destroy life or impair the functions of one or more of the bodily organs. Again, a poison which especially affects the brain centers, producing stupor, is called a narcotic poison. Now, as we shall learn later, the primary effect of alcohol is to deaden the great nerve centers, and hence it is usually classed as a narcotic poison.

When we read about poisons we are apt to think only of those substances that may cause death in a very short time. Among them are laudanum, strychnine, and carbolic acid. But we must remember that there are many poisons which do their work very slowly. Thus, arsenic in large doses may destroy life in a few moments or it may be taken day by day in such small amounts that many months or even years may elapse before death results.

Lead used by painters may be absorbed so slowly that it may take months before its victims learn by severe cramps in the bowels and the "wrist drop" that the poison has been slowly accumulating in the tissues before any outward sign of its action was evident.

138. Alcohol a Poison. Alcoholic liquors may be taken in such quantities at a single dose, either by accident or design, as to paralyze the great nerve centers and cause immediate death. Thus, cases are on record in which whisky has been drunk on a wager and gin taken in ignorance by children in such quantities as to produce deep stupor and death. While alcohol may thus act in large quantities as a quick and powerful poison, in the vast majority of cases it is, of course, taken in comparatively smaller amounts.

Hence, while this action of the narcotic is slower, it is none the less subtle and deadly in its poisonous effect upon the various tissues of the body.

Alcohol thus answers to the definition of a poison because it has an inherent harmful property which on becoming mixed with the blood is capable of destroying life, as would arsenic, opium, and many other deadly drugs.

Remember, then, that **alcohol is a poison** and is classed as such in standard medical dictionaries and by eminent medical authorities.[1]

139. Total Abstinence the Only Safeguard. No one is safe who begins to take any liquor containing alcohol. Entire abstinence is the only safeguard against forming the alcoholic appetite, and the only cure for it when it is formed.

[1] Alcohol is a poison. So is strychnine; so is arsenic; so is opium. It ranks with these agents. — SIR ANDREW CLARK, M.D.

Is alcohol a poison? I reply, Yes. It answers to the description of a poison. It possesses an inherent, deleterious property, which, when introduced into the system, is capable of destroying life, and it has its place with arsenic, belladonna, prussic acid, opium, etc. In its effects upon the living system alcohol is first an irritant, and afterward, when it has entered the circulation, it becomes a narcotic. Were alcohol an irritant only, a man would as soon poison himself with arsenic. The narcotic element is the siren that leads him on to ruin and to death. — WILLARD PARKER, M.D.

A very large number of people are dying day by day, poisoned by alcohol, but not supposed to be poisoned by it. — SIR WILLIAM GULL, M.D.

Alcohol is a virulent poison, and as such should be placed in the list with arsenic, mercury, and other dangerous drugs. — ALFRED CARPENTER, M.D., Examiner of Public Health in the University of London, President of the Council of the British Medical Association.

Compared with the small quantity of adulterants found in spirituous drinks, ethyl alcohol is so significant that it clearly forms the chief poison. — PROFESSOR J. A. SIKORSKY, of the University of Kiev.

Experiments have demonstrated that even a small quantity of alcoholic liquor, either immediately or after a short time, prevents perfect mental action and interferes with the functions of the cells and tissues of the body, impairing self-control by producing progressive paralysis of the judgment and of the will; and has other markedly injurious effects. Hence alcohol must be regarded as a poison and ought not to be classed among foods. — *An International Manifesto against the Use of Alcoholic Beverages*, signed by over eight hundred total abstaining practitioners of medicine in this country and Europe.

Because of the ease with which the alcoholic appetite is roused when it has been once formed, and the power of a very small amount of strong drink to stimulate such an appetite, there may be a real danger in using wine, rum, and brandy as a flavoring for pies, pudding sauces, jellies, or any other article of food.

140. The Danger of Social Drinking. The habit of treating one's friends to beer, wine, or any other alcoholic drink is simply asking them to injure their health at our expense. Such treating is a mark of imprudence rather than an evidence of real courtesy or friendship, and it must be so considered by one who understands the true nature of such substances.

Furnishing wines or liquors at parties, dinners, or other entertainments, or for guests or callers, is virtually offering poisonous drinks, and is never an act of true or intelligent hospitality or real kindness. It may be placing temptation too strong to be resisted in the way of an inherited or acquired appetite for alcohol.

The eminent Dr. Horsley, a professor in University College, London, in closing a lecture recently on the effects of small quantities of alcohol on the brain, said: "The contention so often made that small doses of alcohol, such as people take at meals, have practically no deleterious effect cannot be maintained. From the scientific standpoint total abstinence must be the course if we are to follow the teaching of truth and common sense."

141. The Alcohol Habit. Alcohol, like so many other narcotic poisons, has the peculiar power when taken frequently, even in small quantities, of creating a diseased appetite or craving for itself, which calls for repeated and increasing amounts. This is known as the **alcoholic habit or**

appetite. All natural appetites have natural limits. But the appetite for alcohol, created by the diseased conditions which it has itself produced, has no limit to its baneful effects upon the health.

From the first glass of beer or wine sipped by the boy who is just beginning to drink to the dram of the drunkard whose tissues are poisoned by it, the nature of alcohol is to excite a thirst for more. Whether it is used in the form of wine, beer, cider, rum, or whisky, its character is the same; for the character of any substance depends upon its quality, not its quantity.

The secret of the drunkard's craving for alcohol is in the nature of the drink rather than in the weakness of the drinker.

142. The Oxidation of Small Quantities of Alcohol in the Body. When alcoholic beverages are used in small or moderate quantities, the greater part of their alcohol is burnt up or oxidized within the body. The alcohol thus disposed of gives out a certain amount of energy, as truly as the oxidation of ordinary food materials in the body yields energy.

We must remember, however, that the result to the body is quite different from that of the oxidation of food. When foods like sugar or starch are used as sources of energy there is no injurious effect upon the nervous system; but the use of enough alcohol to supply an appreciable amount of energy impairs the higher functions of the brain, such as the ability to reason accurately or to exercise complete self-control.

143. Alcohol not a Food. Definitions of the word "food" are not always expressed in the same terms, but the following essential points should be included in a

comprehensive definition: A food is a substance whose nature it is, when taken into the system, to build up and repair the body and to supply it with energy for heat and muscular work without injury to any of its tissues.

Alcohol in small quantities, as we have just learned, is oxidized in the body, and its energy transformed into heat, as truly as sugar, starch, or fat. It by no means follows, however, that alcohol is therefore a food in the ordinary sense in which the term "food" is used. Many harmful substances, as ether, morphine, and other powerful drugs, are oxidized within the body and furnish a certain amount of energy, and yet nobody classes these as foods. While it may be true from a purely scientific and technical point of view that alcohol by its oxidation may set free a certain amount of energy within the body, the sum total of its effects is injurious rather than beneficial. Hence there is clearly no good reason for calling alcohol a food in the ordinary meaning of the term.

Standard authorities, moreover, class alcohol as a powerful drug, — a narcotic poison rather than a food. When we stop to think of the possibilities concerned in drinking even a very small quantity of alcoholic liquor, the idea of calling it a food is an evident contradiction of terms.[1]

[1] Alcohol does not act as a food; it cuts short the life of rapidly growing cells or causes them to grow more slowly. — LIONEL S. BEALE, M.D., Professor of Principles and Practice of Medicine, King's College, England.

I find alcohol to be an agent that gives no strength, that reduces the tone of the blood vessels and heart, that reduces the nervous power, that builds up no tissue, and can be of no use to me or any other animal as a substance for food. — SIR HENRY THOMPSON, M.D.

Certainly alcohol cannot be regarded as an efficacious food for muscles, nerve cells, and the like. Not even in a narrow sense can it take the place of a force-generating food material. — ADOLF FICK, M.D., University of Würzburg, Germany.

QUESTIONS ON THE TEXT

1. Of what are fruit juices composed? 2. What happens to these fruit juices if left exposed to air of ordinary temperature? 3. What is meant by nature's great law of decay? Illustrate. 4. What name is given to the process of decay that goes on in fruit juices that are pressed out and left exposed to the air? 5. What does fermentation in its widest sense include? 6. State briefly the law of fermentation. 7. What causes the various processes of decomposition? 8. What would be the condition of the earth if it were not for these minute living forms? 9. To what is the general name "bacteria" applied? 10. What are the shape and size of several different kinds of bacteria?

11. What is mold? Illustrate. 12. Mention three of the more common forms of fermentation. 13. Upon what is alcoholic fermentation in general based? 14. What change in fruit juices and cereals is brought about by fermentation? 15. Explain in full how wine is produced by fermentation. 16. What is the great danger from drinking wine? 17. What are malt liquors? 18. Explain how alcohol is formed by the fermentation of cereals. 19. What can you say of the food value of beer? 20. Does the drinking of beer tend to diminish the use of ardent spirits?

21. Describe the physiological effect of drinking malt liquors. 22. What is the testimony of life-insurance companies in regard to beer drinking? 23. Explain how cider is made by the fermentation of the juice of apples. 24. Explain the process of distillation. 25. From what are the various distilled liquors made? 26. What is a poison? 27. What is a narcotic poison? 28. Show why alcohol is a poison. 29. What is the only safeguard against forming the alcoholic appetite and the only cure when it is formed? 30. What are some of the dangers of social drinking?

31. Explain in full what is meant by the alcohol habit. 32. How does the result of the oxidation of alcohol upon the body differ from that of the oxidation of food? 33. Give the essential points in the definition of a food. 34. Explain why alcohol is not a food in the ordinary meaning of the word. 35. How is alcohol classed by standard authorities?

CHAPTER VI

THE DIGESTION OF FOOD

144. The Object of Digestion. The tissues of the body cannot take up and use the food materials in the form in which they exist in the food we eat. They must first be brought into a condition of solution. This is done that they may be absorbed or be able to make their way through the tissues forming the delicate walls of the alimentary canal.

In the next place, the food materials must undergo certain chemical changes whereby they can be assimilated or taken up by the tissues.

This most wonderful process by which the food materials are made capable of **absorption** and **assimilation** is known as **digestion.**

The special organs concerned in bringing about this marvelous change in the food are the **digestive organs.**

145. The Alimentary Canal. The food tube from the mouth to the lowest part of the intestines is known as the **alimentary canal,** because it is for the alimentation, or feeding, of the body.

Beginning at the mouth, this food tube continues as the **gullet,** or **œsophagus.** It then pierces the diaphragm, which forms the partition between the chest and the abdomen (Figs. 83 and 103).

Lower down the food tube swells out into a large bag called the **stomach.**

The food tube then narrows again into the **small intestine,** which is coiled upon itself in the abdomen. It now expands again into the **large intestine,** from which are discharged the waste materials.

Layers of muscles which help to push along the food surround this long food tube. In and around this tube are many organs called glands.[1] They pour out certain fluids, which moisten the food, change it chemically, and otherwise make it ready to be taken into the blood.

146. The Mouth. The first change which food undergoes when taken into the alimentary canal is in the **mouth.**

In the mouth the food is rolled over by the tongue, mixed with saliva, and

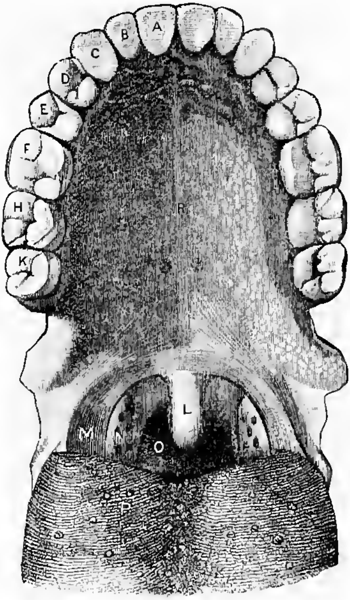

FIG. 63. A View of the Back Part of the Adult Mouth.

The head is represented as having been thrown back, and the tongue drawn forward. *A*, *B*, incisors; *C*, canine; *D*, *E*, bicuspids; *F*, *H*, *K*, molars; *M*, anterior pillar of the fauces; *N*, tonsil; *L*, uvula; *O*, upper part of the pharynx; *P*, tongue drawn forward; *R*, linear ridge, or raphe.

[1] Glands are curious organs of various shapes and sizes, whose special work it is to take out of the blood something to be used again, or to rid it of something to be cast out of the body. Thus, the salivary glands make saliva, or spittle, and the sweat glands make sweat. The liver, which weighs from three to four pounds, is a single gland, and secretes bile; while the glands in the intestines are so very small that they cannot be seen by the naked eye (Fig. 68).

crushed and ground into small pieces by the teeth. This process is called **chewing** or **mastication.**

147. The Teeth. The **teeth** serve to cut and grind the food. They are fastened into the jaws by roots, which sink into the bony sockets somewhat in the same way as a nail is held in a piece of wood.

A child at birth has no teeth; afterwards, however, two sets are developed, one after the other. The first set, or

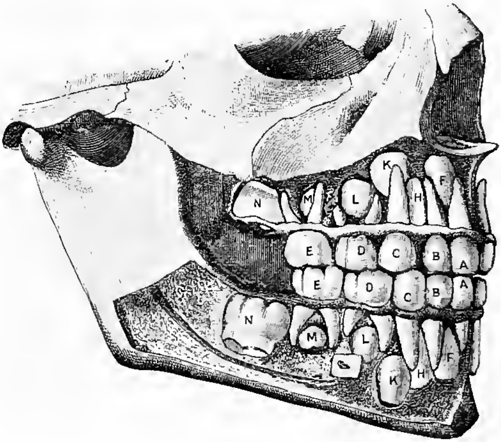

FIG. 64. The Temporary and Permanent Teeth.

Temporary Teeth: *A*, central incisors; *B*, lateral incisors; *C*, canines; *D*, anterior molars; *E*, posterior molars. *Permanent Teeth:* *F*, central incisors; *H*, lateral incisors; *K*, canines; *L*, first bicuspids; *M*, second bicuspids; *N*, first molars.

temporary, often called the **milk** teeth, twenty in number, are shed in childhood. The second set, or **permanent** teeth, thirty-two in number, gradually take their place.

The teeth are arranged in the same way, and number the same in each jaw and in each half of each jaw.

148. The Structure of Teeth. The teeth are made of three materials, — **dentine, cement,** and **enamel.** Dentine, the familiar ivory of commerce, is a bonelike substance which forms the inside and body of the tooth. Outside of this dentine or the root is a layer of cement; but, when the tooth appears above the jaw, the enamel takes the place of the cement. Enamel is a hard, shining material which looks like ivory, and gives a strong protection to the exposed part of the tooth, called the *crown.*

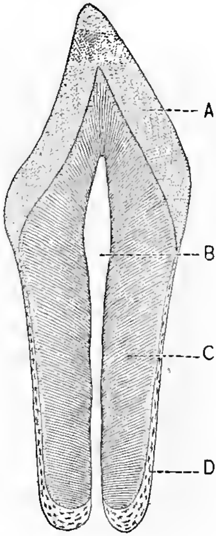

FIG. 65. BLACKBOARD SKETCH.

Longitudinal Section of a Tooth.

A, enamel; *B*, pulp cavity; *C*, dentine; *D*, cement.

Inside of each tooth is a space which holds a delicate substance called the *pulp*, well supplied with nerves and blood vessels which enter at the root of the tooth.

149. The Different Kinds of Teeth. Beginning at the center of the jaw, there are eight **incisors,** or cutting teeth, two on each side. They have sharp, chisel-like edges, which cut up the food. These teeth are largely developed in gnawing animals, such as rabbits, squirrels, rats, and beavers.

Then come the **canine,** or dog teeth, two in each jaw, so called because they are strongly developed in dogs, cats, tigers, and other flesh-eating animals. The two upper canines are commonly known as the *eye* teeth, and the two lower as the *stomach* teeth.

Next come the **bicuspids,** four in each jaw. They have two points, or cusps, for grinding the food.

Next in order, after the bicuspids, come the largest and strongest teeth, which do the hardest work. They are called **molars**, or grinders. There are six of them in each jaw. They have broad crowns, with four or five cusps or ridges for grinding. The last molars are commonly called the "wisdom teeth," because they do not usually appear before the age of twenty, or the "age of wisdom" (Sec. 178).

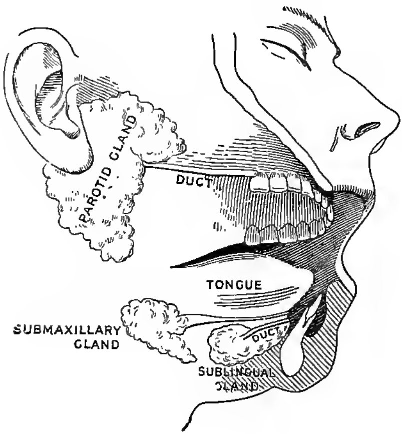

FIG. 66. BLACKBOARD SKETCH.
Salivary Glands of the Right Side.

Experiment 28. Get a specimen of each kind of tooth if possible. A dentist friend will give you what you need. Use a very fine saw to cut a perfect molar in two lengthwise. If need be, crack the tooth with a hammer.

Note its structure in a general way, — its crown, cusps, roots, enamel, dentine, pulp cavity, etc.

Make a blackboard sketch of a tooth on a large scale, using colored crayon to make plain the various parts (Fig. 65).

Experiment 29. With the help of a mirror, let each pupil locate his own teeth. Note the incisors, eye teeth, bicuspids, molars, and wisdom teeth, if any. In the same way, note the teeth of some schoolmate.

150. The Salivary Glands. While the food is being chewed it is moistened by the **saliva**, or spittle, which flows into the mouth from six little glands. They are known as the **salivary glands**. There are three of them on each side.

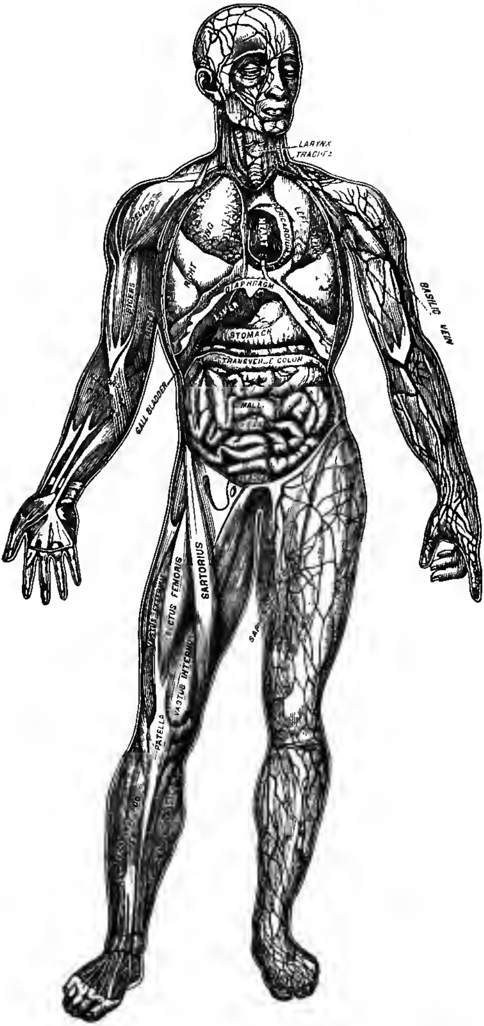

FIG. 67. The Principal Organs of the Thorax and Abdomen.

The principal muscles are seen on the left, and superficial veins on the right.

The **parotid gland** lies below and in front of each ear.[1]

The **submaxillary gland** is under the lower jaw.

The **sublingual gland** is found under the tongue, in the floor of the mouth.

Each salivary gland opens into the mouth by a little duct. Each has a certain resemblance to a bunch of grapes, with a tube for a stalk.

151. The Action of Saliva. Saliva flows rapidly into the mouth while we are chewing food. About two pints of saliva are secreted in the course of a day. Sometimes

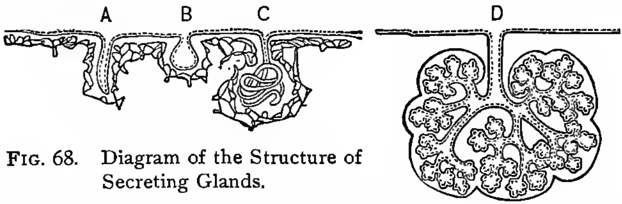

FIG. 68. Diagram of the Structure of Secreting Glands.

A, simple tubular gland; *B*, gland with mouth shut and sac formed; *C*, gland with a coiled tube; *D*, plan of part of a racemose gland.

these glands are busily at work even before we actually taste food. The saliva will flow into the mouth even at the sight, smell, or thought of food. This is commonly known as "making the mouth water."

The saliva mixes with food and softens it, and aids in speech by keeping the mouth moist. It also acts upon the starchy matters in food through its ferment, called *ptyalin*, and changes them into a form of sugar known as *maltose*.

Experiment 30. *To make the saliva flow.* Think of some favorite article of food, and note the flow of saliva. Push a lead pencil or the finger to and fro in the mouth several times, and note the flow of saliva.

[1] This gland, especially in childhood, sometimes becomes inflamed and swollen in the disease familiarly known as "mumps."

Experiment 31. *To show the action of saliva on starch.* Chew slowly a piece of fresh bread.[1] Note how sweet it tastes after it is well wet with the saliva. Do the same with a mouthful of paste made of pure arrowroot (almost pure starch) and boiling water, and allowed to cool.

152. What is meant by Secretion. It is necessary to explain at this point the exact meaning of secretion and excretion. The word "secretion" comes from a Latin word which means to sift or separate; excretion comes from the Latin, and means to sift out from. Both words are used to express the sifting of some substance from the blood.

A **secretion** is something taken from the blood to be used again in the body for some special purpose; while an **excretion** is waste matter, and is thrown out of the body entirely. Thus, the salivary glands secrete the saliva,

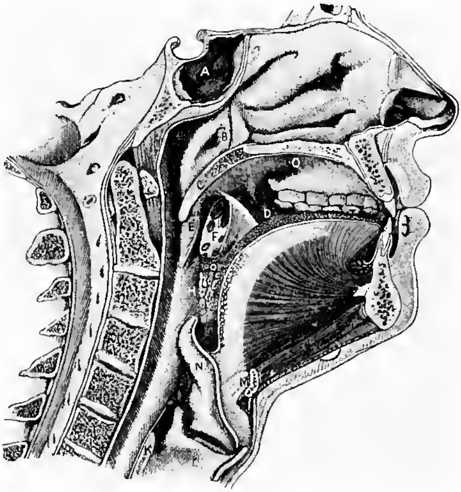

FIG. 69. Cavities of the Mouth, Pharynx, etc.

Section in the middle line designed to show the mouth in its relations to the nasal fossæ, the pharynx, and the larynx. *A*, sphenoidal sinus; *B*, internal orifice of Eustachian tube; *C*, velum palati; *D*, anterior pillar of soft palate; *E*, posterior pillar of soft palate; *F*, tonsil; *H*, lingual portion of the pharynx; *K*, lower portion of the pharynx; *L*, larynx; *M*, section of hyoid bone; *N*, epiglottis; *O*, palatine arch.

[1] Chew pieces of the brown crust of the bread. It is quite sweet and readily dissolves, because, exposed to more heat than the rest of the loaf, the starch has been changed into dextrin before the bread left the oven. Hence crust and toast are favorite articles of food, especially with old people.

and the liver secretes the bile. Sweat is an excretion thrown off from the body by the sweat glands.

Excretion will be described in Chapter IX.

153. How Food is swallowed. The food is now ready to be swallowed. The soft, moist mass is carried backwards by the tongue and the muscles of the mouth into the funnel-shaped part above the gullet, called the **pharynx.** The soft palate moves upwards and backwards, so as to prevent the food from passing into the nose[1] (Fig. 69).

Now, besides the opening from the pharynx into the gullet, there is also one into the windpipe. To prevent the food from getting into this opening and choking us, the top of the windpipe is protected by a little lid, a kind of trapdoor, called the **epiglottis** (Figs. 101 and 174).

When we swallow, the tongue, raised and pushed backwards, shuts this little lid; and thus a bridge is made, over which the food passes downwards into and through the gullet, and thence into the stomach.

Sometimes, however, a morsel of food "goes the wrong way," — that is, is drawn into the opening of the windpipe, or down into the air tubes, — and then violent coughing follows: by this means it may be brought up again. If the substance is hard and large, like a boot button, an orange seed, or a peanut, a person, especially a child, may be choked to death.

Experiment 32. Open the mouth wide; press down the back of the tongue gently with the handle of a teaspoon. With the aid of strong sunlight and a hand mirror the epiglottis may be seen.

[1] After an attack of diphtheria the parts of the throat are sometimes partially paralyzed. The soft palate is not able to shut off this passage into the nose; as a result, milk and other food often come up through the nose.

154. The Gullet. The **gullet**, or food pipe, is a tube about nine inches long, hanging loosely behind the windpipe. Its thick walls are provided with hooplike muscles which contract with a wavelike motion, well seen when a horse is

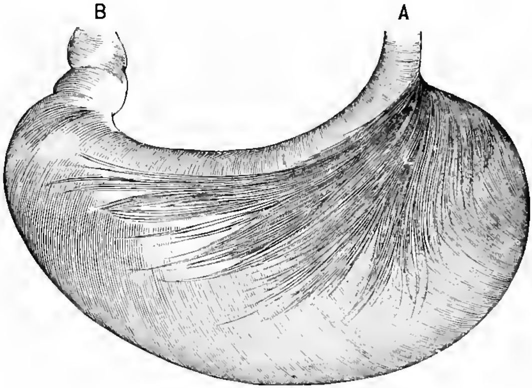

Fig. 70. Blackboard Sketch.

The Stomach.

A, cardiac end; *B*, pyloric end.

drinking water, and so push the food along towards the stomach. The pellet of food is pushed downwards by these muscles[1] in some such way as we would push any substance along inside of a rubber tube (Fig. 83).

Experiment 33. Place the fingers on the "Adam's apple" (Sec. 379). Pretend to swallow something, and you can feel the upper part of the windpipe and get a very fair idea of the action of the epiglottis and the closing of its lid, thus covering the entrance and preventing the passage of food into the windpipe.

[1] It is important to remember that, in swallowing, the food and drink do not simply *fall* down the gullet. Their passage is controlled by the muscles in such a way that they grip successive portions swallowed, and

155. The Stomach. The food, a moistened, partly digested mass, has now reached the **stomach,** which is a pear-shaped bag, or pouch, capable of holding about four pints. It lies under the diaphragm, chiefly on the left side of the abdomen.

The stomach has two openings. The opening, or ring, through which the food enters, is called the *cardiac* orifice.

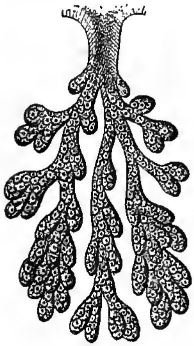

FIG. 71. A Gastric Gland.

The opening at the right end, where the intestines begin and by which food leaves the stomach, is known as the *pyloric* orifice. It is guarded by a kind of valve called the **pylorus,** or gate keeper.

156. The Coats of the Stomach. The outer coat of the stomach is the smooth, glistening serous membrane which lines the abdomen, — the *peritoneum.*

The inner lining, or mucous membrane, of the stomach is loose and wrinkled when the stomach is empty, and smoothed out when it is full of food. Between the outer smooth coat and the inner lining lies the muscular coat.

The inner coat of the stomach has its surface honeycombed with millions of little pits. We have all seen this in tripe. In the floor of each of these tiny pits a number of tubes open. These are the openings of the *gastric glands.*

pass them along. In swallowing a pill there is the same process. The smaller the pill, the greater the difficulty oftentimes in swallowing, because the muscles have more trouble in getting the necessary grasp on it. Some of us have seen an acrobat or juggler stand on his head, and drink a glass of water, and even eat in this position. We may see the same thing when we watch a horse or a cow drinking from a pail of water on the ground.

157. Digestion in the Stomach. The moment the food reaches the stomach, the muscles begin to contract, and a spiral wave of motion begins, becoming more rapid as digestion goes on. The food is rolled over and over, and thoroughly mixed with the gastric juice. Two rings, one at the entrance and the other at the outlet, keep the food in the stomach while it is being churned about and digested.

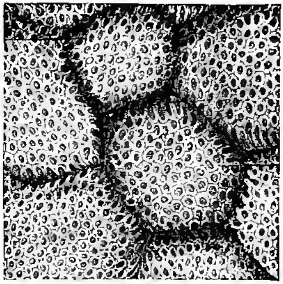

FIG. 72. The Inner Surface of the Stomach, from which the Epithelium has been removed, showing the Openings of Gastric Glands.

Magnified 20 diameters.

158. The Gastric Juice. Soon after food enters the stomach, drops of fluid collect at the mouths of the gastric glands and trickle down its walls to mix with the food. This fluid is known as the **gastric juice.**

The gastric juice is a clear, almost colorless fluid, with a sour taste and odor. It contains a peculiar substance called *pepsin,* and an acid, both of which are necessary to the digestion of food in the stomach. The amount of gastric juice has been variously estimated, — all the way from five to fourteen pounds daily.

Experiment 34. *To show how the wall of the stomach looks.* The wall of the pig's stomach resembles that of the human stomach. Get from the market a piece of a pig's stomach. Cut off bits of it and examine it thoroughly with a hand lens. Scrape off the inner, or mucous, coat with the edge of a very sharp knife. Find the openings of the gastric tubes with the help of a magnifying glass. Pick with fine needles until the fibers of the muscular coat are found. Contrast the appearance of the pig's stomach with that of a cow by examining a piece of tripe.

159. The Action of the Gastric Juice. The gastric juice consists of water with a little hydrochloric acid and two ferments called *pepsin* and *rennin*. The pepsin, acting in the presence of a weak acid, turns the proteid food stuffs into what are called *peptones*, which are soluble and capable of being absorbed into the blood.

The gastric juice has no action on starchy foods, neither does it act on fats, except to set free the fat from the connective tissue which contains it.

Experiment 35. *To show the action of gastric juice on milk.* Mix two teaspoonfuls of fresh milk in a test tube with a few drops of artificial gastric juice,[1] and keep at about 100° F. In a short time the milk curdles so that the tube can be inverted without the curd falling out. By and by *whey* is squeezed out of the clot.

160. Passage of the Food into the Intestines. After two or three hours of digestion, the food in the stomach is reduced to a pulpy and almost fluid condition. It now takes on the appearance of pea soup, usually of a grayish color, and is called **chyme.**

After one to four hours, the chyme begins to move on in successive portions into the first part of the small intestine. The ringlike muscles of the pylorus relax at intervals to allow the muscles of the stomach to force the partly digested mass into the intestines.

This action is often repeated until even the indigestible masses which the gastric juice cannot break down are crowded out of the stomach into the intestines. From three to four hours after a meal the stomach is quite emptied.

[1] An artificial gastric juice may be obtained for experimental purposes by dissolving about ten grains of pepsin powder (made by some reputable manufacturer and obtained of any druggist) in half a pint of water and adding perhaps from fifteen to twenty drops of strong hydrochloric acid, or about six times as much of the dilute acid.

Some of the food, while in the stomach, is absorbed into the blood current. The peptones and some sugar pass

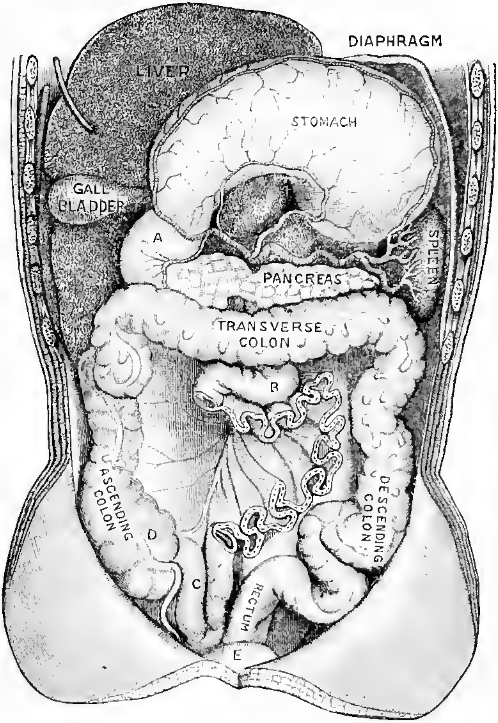

FIG. 73. Showing the Relations of the Stomach, Liver, Intestines, Spleen, and other Organs of the Abdomen. (Front view.)

A, duodenum; *B*, upper end of the small intestine; *C*, lower end of the small intestine; *D*, cæcum; *E*, bladder. The liver and stomach are drawn up, and portions of the small intestine have been cut away.

through the lining membrane into the capillaries which form a close network in the mucous membrane.

161. The Small Intestine. The intestines consist of a long tube which fills the greater part of the abdomen. They are divided into the **small intestine,** about twenty-five feet long, and the **large intestine,** about five feet in length.

The first portion of the small intestine,[1] which is directly continued from the stomach, is called the **duodenum,** because it is about twelve fingers' breadth long, — that is, about eight inches.

Let us now see what takes place in the duodenum. Two tubes, or ducts, unite and enter it. One comes from the liver and the gall bladder, and brings the **bile**; the other from the pancreas, and brings the **pancreatic juice.** These two tubes unite, and enter the duodenum at the same place.

162. The Liver and the Work it does. The **liver** is a large reddish-brown organ situated just under the diaphragm, and on the right side. It is the largest gland in the body, and weighs about three and one-half pounds. The liver secretes in the course of a day about two pints of an important fluid called the **bile.** Some of it is stored up in a kind of little pear-shaped bag attached to the liver itself, and called the **gall bladder.**

The liver also makes a material which resembles starch, called *glycogen,* or *liver sugar.* This is stored in the liver when food is plentiful, and is used up during starvation or during muscular work.

163. The Bile and how it helps in Digestion. The **bile** is a greenish-yellow, bitter fluid, but, when acted upon by the gastric juice, it takes on a distinctly yellow or greenish hue; hence the appearance of vomited bile.

[1] The small intestine includes three parts, — duodenum, jejunum, and ileum. The large intestine includes the cæcum, colon, and rectum (Fig. 73).

The chief use of the bile is to help digest the fatty foods upon which the gastric juice does not act. The bile also

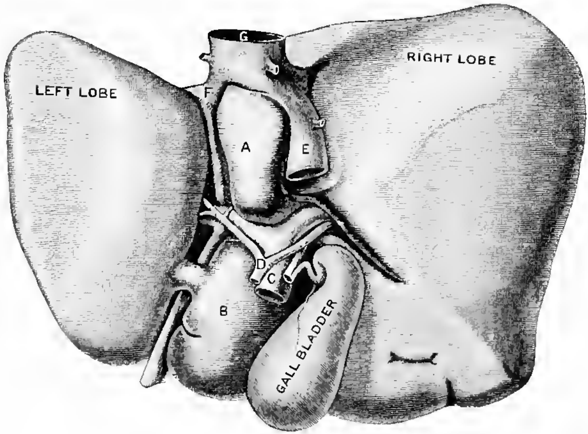

FIG. 74. The Liver seen from Below and Behind.

A and *B*, smaller lobes of the liver; *C*, portal vein; *D*, hepatic artery; *E*, inferior vena cava; *F*, trunk of left hepatic vein; *G*, hepatic vein.

contains materials separated from the blood which are of no further use to the body and which must be cast out before they do mischief.

Experiment 36. *To show the action of bile on fats.* Mix three teaspoonfuls of bile[1] with a half teaspoonful of sweet oil. Shake well, and keep the tube in a water bath at about 100° F. A very good emulsion is obtained.

[1] Obtain from the butcher some ox bile. Note its bitter taste, peculiar odor, and greenish color. It is alkaline or neutral to litmus paper. Pour it from one vessel to another, and note that strings of mucus (from the lining membrane of the gall bladder) connect one vessel with the other. It is best to precipitate the mucus by acetic acid before making experiments, and to dilute the clear liquid with a little distilled water.

164. The Pancreatic Juice and what it does. The **pancreatic juice** is secreted by a long, narrow, flattened gland called the **pancreas**, or sweetbread. It lies behind the stomach and is often said to resemble a dog's tongue (Fig. 73).

The pancreatic juice, by means of its three ferments, finishes the work which the saliva began. It acts chiefly upon the starchy foods which have escaped the action of the saliva, and changes them into sugar. It also follows up the work of the gastric juice, and acts upon the proteids which have not been digested in the stomach, changing them into peptones.

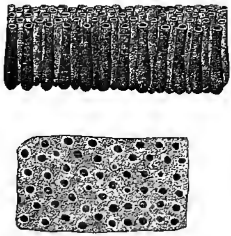

FIG. 75. Vertical Section of Intestinal Villi; Cross-Section below, with Black Dots representing Glandular Openings.

The pancreatic juice acts upon the drops of fat in such a way as to split them into glycerin and a fatty acid. The latter now unites with the alkali of the pancreatic juice and the bile, and forms soap. It also makes what is called an emulsion out of the fats; that is to say, it breaks them up into tiny particles and they become white like milk.

Experiment 37. *To show the action of pancreatic juice on the albuminous ingredients (casein) of milk.* Into a half-pint bottle (an infant's nursing bottle will answer and is easily obtained) put two tablespoonfuls of cold water; add one grain of pancreatin, and as much baking soda as can be taken up on the point of a penknife. Shake well, and add four tablespoonfuls of cold, fresh milk. Shake again. Now set the bottle into a basin of hot water (as hot as one can bear the hand in), and let it stand for about forty-five minutes.

Take a small quantity of milk in a test tube, and stir in a few drops of vinegar. A thick curd of casein will be seen. Upon applying the same test to the digested milk, no curd will be made. The pancreatic ferment (trypsin) has digested the casein into peptone, which does not curdle.

165. How Food is absorbed. The souplike mass which left the stomach under the name of chyme has now been changed into a thick cream called **chyle.** Squeezed slowly along the intestines by the wavelike motions of the muscular walls, the food materials that have been digested and turned into a soluble form are absorbed. In other words, they pass from the inside of the intestines into the blood vessels and the lacteals lying in the intestinal walls.

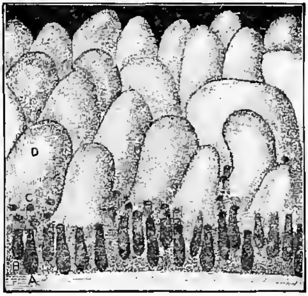

FIG. 76. Glands and Villi of the Small Intestine.

Magnified 40 diameters.

A, *B*, glands seen in vertical section with their orifices at *C* opening upon the membrane between the villi; *D*, villus.

The process by which the digested materials are taken into the blood is called **absorption.** It is by no means a process that is confined to the alimentary canal, but one that is going on in every tissue of the body.

This is done chiefly by two sets of vessels, — first, by the **lacteals,** or **lymphatics**; second, by the **blood vessels.**

166. The Work done by the Lacteals. The inner surface of the small intestine is not smooth and shiny, like the outside, but has a velvety appearance. This is because it is crowded with millions of little club-shaped threads which project into the cavity of the intestine.

These projections are called **villi,** meaning tufts of hair. They are tiny threads, about one thirtieth of an inch long; and a five-cent piece would cover five hundred of them. They are set side by side not unlike the pile on velvet. These villi are not found in the large intestine.

In each one of these villi is a network of the finest blood vessels, and a tube, or canal, called a **lacteal**, so called from a Latin word meaning milky, because it carries a white, milky fluid. Millions of these lacteals dip down into the small intestine, like little root fibers, and suck up the droplets of fat or the glycerin and soaps made from them.

The lacteals, after passing through a number of glands — like way stations on a railroad — in the abdomen, unite

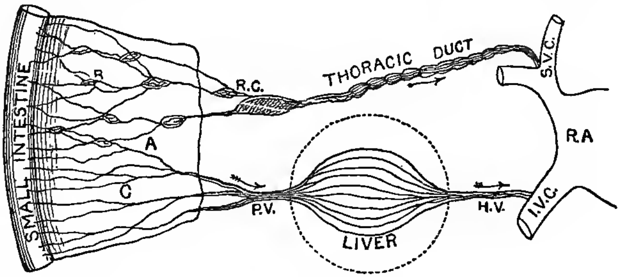

FIG. 77. BLACKBOARD SKETCH.

Diagram of Intestinal Absorption.

A, a fold of peritoneum; *B*, lacteals and lymphatic glands; *C*, veins of intestines; *R.C.*, receptacle of the chyle (receptaculum chyli); *P.V.*, portal vein; *H.V.*, hepatic veins; *S.V.C.*, superior vena cava; *R.A.*, right auricle of the heart; *I.V.C.*, inferior vena cava.

into larger tubes, and finally open into the saclike expansion of the lower end of the thoracic duct, known as the **receptaculum chyli**. Into this are poured not only the contents of the lacteals but also of the lymphatic vessels of the lower limbs (Fig. 128).

167. The Thoracic Duct. Sooner or later most of the small lymphatics pour their contents into the **thoracic duct**. This is a tube about as large as a goose quill, which lies in front of the backbone. It serves to carry the nutritive

material obtained from the food and pours it into the blood current at the junction of the great veins on the left side of the head with those of the left arm (Fig. 103).

The remaining lymphatics, chiefly those on the right side, are connected with the great veins of the right side.

168. The Work done by the Lymphatics. In nearly every tissue of the body there is a marvelous network of vessels, precisely like the lacteals, known as the **lymphatics**. They seem to start out of the part in which they are found, like the rootlets of a plant in the soil. The tiny roots join together and make larger roots. They carry a fluid called **lymph**, very

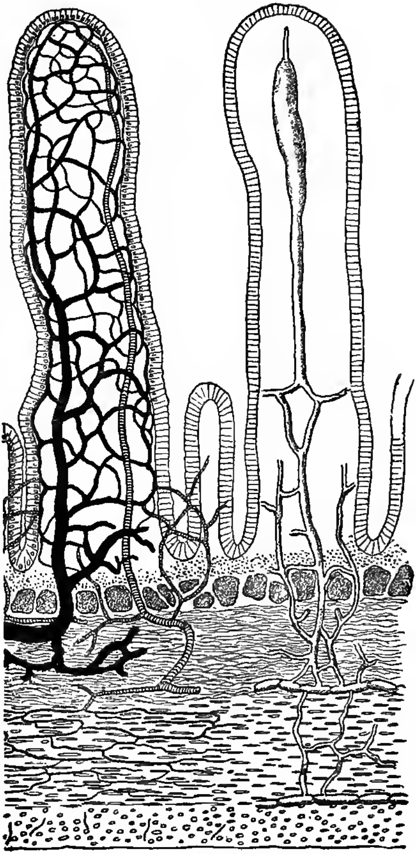

Fig. 78. Blackboard Sketch.
Diagram of a Transverse Section of the Small Intestine.

In the figure on the left are seen the artery and vein of a villus. In the right figure are represented the central lacteal of villus, with plexus of lymph vessels at the base. The mucous, submucous, muscular, and serous coats are indicated at the base of the right-hand figure. The epithelium of each villus is well shown.

much like blood without the red corpuscles. It is to be remembered that the lacteals are really the lymphatics which begin in the villi of the small intestine.

The lymphatics have little round bodies, about the size of hazelnuts, at many points of their course, scattered like stations along a line of railroad, which bodies are called **lymphatic glands**. They seem to be a kind of magical workshops to make over the lymph in some way, and to fit it for being poured into the blood (Figs. 80 and 81).

Nature, like a careful housekeeper, allows nothing to go to waste that can be of any service to the body.

169. The Spleen and Other Ductless Glands. There are in the body a number of organs called "ductless glands," because they have no ducts or canals along which may be carried the products of their work. Their products are carried off by the blood which flows through them.

The **spleen** is situated in the abdomen on the left side, and just behind the stomach. It is about five inches long, of a deep red color, and full of blood (Figs. 73 and 128).

The spleen appears to take some part in the formation of blood corpuscles. In certain diseases, like malarial fever, it may become remarkably enlarged.

The **thyroid gland** is situated beneath the muscles of the neck, on each side of the windpipe. It is greatly enlarged in the disease called goitre.

The **thymus gland** is situated around the windpipe, behind the upper part of the breast bone. Its use is not certainly known. It exists only during early life.

The **suprarenal capsules** are two little glands, one perched on the upper edge of each kidney, shaped something like a cocked hat. Nothing definite is known about them (Fig. 128).

170. Absorption by the Blood Vessels. We have just learned that the fats for the most part get into the blood

current by a roundabout way, — that is, into the lacteals, and thence into the other lymphatics and the thoracic duct.

The peptones and sugar are also carried into the main blood current in a roundabout way. They are taken up by the tiny blood vessels of the villi and then carried along the portal vein to the liver, and are there acted upon before they reach the general blood stream. (See *Portal Circulation*, Sec. 210.)

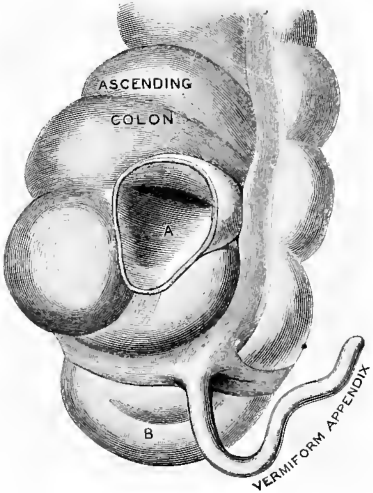

FIG. 79. The Vermiform Appendix.

A, a portion of the colon laid open to show the valve between the large and small intestine; *B*, the cæcum.

171. The Large Intestine. The **large intestine,** which is about five feet long, first passes up the right side of the abdomen, then across under the liver and stomach, and, lastly, descends on the left side of the abdomen. It then bends sharply and ends in the rectum in the middle line of the body (Fig. 73).

Most of the food material which is of any use to the body has been absorbed in the small intestine. The large intestine absorbs a good deal of the remainder, especially water.

This part of the digestive canal also serves as a kind of temporary storehouse for indigestible or waste materials which are to be cast out of the body.[1]

[1] The vermiform appendix, inflammation of which is known as *appendicitis*, is a curious offshoot from the large intestine near the point where it

172. How much to eat. The quantity of food which is needed to keep the body in good health varies greatly according to circumstances. The greater the amount of exercise, the more food is called for to supply the waste.

During the time of growth, a still greater quantity is needed to build up new tissues; hence growing children generally have a good appetite and a vigorous digestion. This is often true of persons who are recovering from some long and wasting sickness.

The quantity of food also depends very much upon one's business. Those who work hard and long need a goodly amount of nutritious food. Those who work indoors can get along with a smaller quantity. In cold weather, or in cold climates, a greater quantity of food is necessary than in warm weather or in a tropical climate.

173. The Ill Effects of eating too much. An appetite for plain, simple, well-cooked food is a safe guide to follow. Every person in good health and with moderate exercise should have a keen appetite for his food, and enjoy it.

Young, growing, and vigorous persons should eat plain food until the appetite is fully satisfied, provided they have enough exercise, both mental and bodily.

It is easy to know when we are eating too much. An overworked stomach makes its condition known by a sense of fullness, uneasiness, drowsiness after meals, and sometimes a real distress.

is joined by the small intestine. It is a hollow tube about three or four inches long, and about the thickness of a lead pencil. From a surgical point of view, it is of great importance because it is subject to sudden inflammation. In many cases an operation is necessary for the relief of the patient. The great English surgeon, Treves, operated one thousand times for appendicitis without the loss of a single patient. The use of antiseptics in recent surgery has made such brilliant results possible (Fig. 79).

If we are in the habit of eating too much and too rich food, the complexion is apt to be muddy, the face is more or less covered with blotches and pimples, the breath has an unpleasant odor, and the general appearance is dull and unhealthy.

174. What to eat. We can safely eat some animal food every day, yet it is well to remember that the vegetable

FIG. 80. Superficial Lymphatics of the Foot.

albumins supply all that is needed for the nourishment of the body.

A strong, hearty person may eat half a pound or so of meat daily; yet he should take other foods, such as bread, oatmeal, beans, rice, and milk. These foods are all good, all cheap, all digestible, and all palatable.

Vegetable foods are less stimulating than animal. Hence they are more suitable for children, for whom the plainest

and simplest diet is the best. It is much better for a child to go to bed on a supper of oatmeal, baked apples, or bread and milk than after one of cake, pie, and fried meat.

Students must also attend carefully to their diet. It is much better to begin a day's study with a breakfast of oatmeal, stale bread, a soft-boiled egg, and a glass of milk than with one of strong coffee, sausage, and hot biscuit.

175. When to eat. Three meals a day should be eaten at regular times. These should be arranged according to one's occupation as far as possible. The stomach, like other organs, does its work best when its tasks are done at regular periods. Hence regularity in eating is of the utmost importance.

Eating between mealtimes should be strictly avoided, for it robs the stomach of its needed rest. Food eaten when the body and mind are tired, is not well digested.

Rest, even for a few minutes, should be taken before eating a full meal. It is a good plan to lie down, or sit quietly and read, for fifteen minutes before eating.

The state of the mind has a great deal to do with digestion. Sudden fear or joy, or unexpected news, may take away the appetite at once. Hence, so far as we can, we should laugh and talk at our meals, and drive away all anxious thoughts and unpleasant topics of discussion. If hunger is a good sauce, so also is a hearty laugh.

176. The Time to eat. We should not eat a hearty meal for at least two hours before going to bed. We should make it a point not to omit a meal unless forced to do so. Children, and even grown-up people, often have the bad habit of going to school or to work in a hurry, without eating any breakfast. There is sure to be an "all-gone" feeling at the stomach before another mealtime.

Severe exercise and hard study just after a full meal are very apt to check digestion. The reason is plain: after a full meal, extra blood is needed to help the stomach digest its food. If, in addition to this, extra blood is needed to help the muscles or brain, digestion will be hindered, and a feeling of dullness and heaviness follows. This, in time, often results in poor digestion, or, as it is often called, indigestion or dyspepsia.

177. Hints about Eating. Eat slowly, and thoroughly chew the food. Do not take too much drink with the food. Our teeth were made to chew our food, and the saliva to

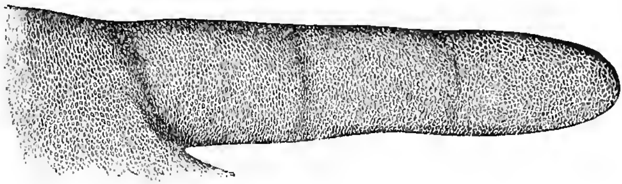

FIG. 81. Superficial Lymphatics of the Finger.

moisten it and help digestion. If the food is well chewed, the saliva and the gastric juice act more readily. It is not only bad manners to eat rapidly, but it is a violation of the simplest law of digestion.

If we take too much drink with our meals, the flow of the saliva is checked, and digestion is thus hindered. Rapid eating, with a great deal of drink to wash down the food, is almost sure to result in dyspepsia.

Do not take food and drink too hot or too cold. Hot bread and hot tea and coffee often injure the enamel of the teeth, and disturb the action of the stomach. If the food and drink are taken too cold, undue heat is taken from the stomach, and digestion is delayed.

It is not wise to bolster a flagging appetite with highly spiced food and bitter drinks. An undue amount of pepper, mustard, horse-radish, pickles, fancy meat dressings, and highly seasoned sauces may stimulate digestion for a time, but, used in excess, they soon weaken it.

177 a. Proper Care of the Bowels. Irregularity in eating, the eating of rich pastry, too much finely bolted flour, and not enough fruit and vegetables, negligence or carelessness in attending to a regular daily evacuation of the bowels, lead to the very common and distressing trouble known as *constipation.*

Do not get into the habit of using any of the numerous proprietary medicines to secure a proper action of the bowels. For the most part they are only of benefit for the time and rarely remove the cause of constipation.

We must pay strict attention to the proper action of the bowels. The formation of a regular habit is of the utmost importance. The bowels can be trained to act at a certain time every day. Take great pains to eat enough coarse food, such as oatmeal, corn bread, vegetables, stewed prunes, dates, figs, etc. Drink a glass of water just after getting out of bed in the morning. Vigorous muscular exercise is a valuable help.

178. Care of the Teeth. The teeth should be thoroughly cleansed night and morning with a soft brush and warm water. Castile soap and some simple tooth powder with no grit in it may be used. The brush should be used on the inner side or back of the teeth as well as on the front.

Great care should be taken in the use of wooden toothpicks. What is known as surgeon's floss or silk, or even common silk thread, when drawn between the teeth, is quite effective in removing particles of food.

The enamel if once broken or destroyed is never renewed. The tooth is left to decay, slowly but surely; hence we

must be on our guard against certain things which may injure the enamel.

Picking the teeth with pins and needles is hurtful. We should never crack nuts, crush hard candy, or bite off stout thread with the teeth. The continued use of gritty and cheap tooth powders, and very hot food and drink often injure the enamel.

The greatest care should be taken in saving the teeth. The last resort of all is to lose a tooth by having it extracted. A skilled dentist can save almost anything in the form of a tooth.

179. Effect of Alcohol upon Mucous Membranes. Alcohol is a distinct irritant of the mucous membranes. Thus, when raw spirit is taken into the mouth, it causes a burning sensation. When diluted it does the same thing, but of course in a less irritating way. By this irritation the epithelial cells of the mucous membranes of the mouth, as well as the salivary glands, secrete an unusual amount of water. This gives rise to a sense of dryness and of thirst.[1] The mucous membrane of the stomach is irritated in a similar way.

180. General Effect of Alcohol on the Stomach. Alcohol acts as a mild or powerful irritant of the stomach according as it is taken diluted or strong. Its habitual use leads to distressing forms of disease of the stomach. If we could look into the stomach, as Dr. Beaumont looked into the stomach of Alexis St. Martin, just after taking a drink of raw spirit, we should find that the inner surface would be

[1] A noted French physiologist, M. Lancereaux, has found that the use of alcoholic drinks produces a softening of the salivary glands, together with other changes in the tissue composing them. This causes alterations in the saliva itself and accounts for the dryness of the mouth so common among persons addicted to the use of alcohol.

bright red where the alcohol touched it, — far more so than after taking food. Alcohol irritates the lining of the stomach and dilates the tiny blood vessels.

181. Effect of Alcohol on the Digestive Powers of the Gastric Juice. Alcohol, like any other irritant of the stomach, causes the gastric juice to flow in an excessive amount, as the eye, when injured, becomes flooded with tears. The digestive power of the gastric juice is at the same time either diminished or seriously impaired by the precipitation of its pepsin. This hinders digestion, because the solvent power of the gastric juice is diminished.

If this unnatural excitement of the glands of the stomach is kept up for some time, an extra amount of useless work is thrown upon the gastric glands and they become less able to do their normal work.

The structural alterations that the habitual use of alcohol may induce, and the action of this agent on the pepsin, may seriously impair the digestive power. Hence it is that those who are habitual consumers of alcoholic liquors often suffer from disorders of digestion. Heartburn, water brash, acid stomach, and a peculiar retching in the morning may thus be produced.

If the amount of alcohol be increased, or the repetition become frequent, some part of it undergoes acid fermentation in the stomach, and acid eructations or vomitings occur. With these disturbances may be associated loss of appetite, feeble digestion, sallowness, mental depression, and headache.

182. The Final Effect upon the Stomach of the Long-Continued Use of Alcohol. Now, when these alcoholic liquors are poured into the stomach for days, weeks, and even for years, it is no wonder that their long-continued

use causes the coats of the stomach to become altered in their structure. There is a chronic inflammation of the inner coats, the walls of the stomach become thicker and harder, and traces of ulceration are often found. Because the stomach is thus inflamed and unable to digest food properly from the habitual use of strong drink, many other important organs of the body suffer as a result.[1]

183. The Case of Alexis St. Martin. The effect of alcoholic liquors upon gastric digestion was studied many years ago by Dr. Beaumont and others, in the case of Alexis St. Martin, a French Canadian. This man met with a gunshot wound which left a permanent opening into his stomach, guarded by a little valve of mucous membrane, Through this opening the lining of the stomach could be seen, the temperature ascertained, and numerous experiments made as to the digestibility of various kinds of food. In this remarkable case it was observed by looking directly into his stomach that when a wholesome dinner was digesting in good order, a glass of gin arrested the process, which was not continued until the alcohol had passed out of the stomach.

[1] Nothing could be further removed from the truth than the popular notion that alcohol, at least in the form of certain wines, is helpful to digestion. Roberts showed, years ago, that alcohol, even in small doses, diminished the activity of the stomach in the digestion of proteids. Gluzinski showed, ten years ago, that alcohol causes an arrest in the secretion of pepsin, and also in its action upon food. Wolff showed that the habitual use of alcohol produces disorder of the stomach to such a degree as to render it incapable of responding to the normal excitation of food. Blumenau says that alcohol manifests a decidedly unfavorable influence on the course of normal digestion, even when taken in small quantities, and injures the normal digestive functions. Hugounence found that all wines, without exception, prevent the action of pepsin upon proteids. The most harmful are those which contain large quantities of alcohol, cream of tartar, or coloring matter. — WINFIELD S. HALL, M.D., Professor of Physiology in Northwestern University Medical School, Chicago.

Many experiments have been made by drawing off the contents of the stomach with a siphon, during various stages of digestion. When alcohol had been taken it was found that the strong drink suspended the digestion of food for some time while it remained in the stomach, and that only after the alcohol left the stomach did digestion go on at a fair rate.[1]

[1] Under the influence of alcohol, the acidity of the gastric juice and the quantity of hydrochloric acid, as well as the digestive power of the gastric juice, is diminished. This enfeebling of the digestion is especially pronounced in persons accustomed to the use of alcohol. — PROFESSOR KOCHLAKOFF, St. Petersburg.

When constantly irritated by the direct action of alcoholic drinks, the stomach gradually undergoes lasting structural changes. Its vessels remain dilated and congested, its connective tissue becomes excessive, and its power of secreting gastric juice diminishes. — H. NEWELL MARTIN, M.D.

At last the alcohol enters the stomach. Wherever it touches it causes irritation, then paralysis of the nerves and congestion of the mucous membranes. It mixes with the gastric juice and diminishes its digestive power. At length it comes to pass that the stomach can no longer fulfill its normal functions. It becomes flabby and inert; digestion becomes slow and difficult; the appetite is lost. Soon after, the mucous membrane, losing its resisting power, corrodes, small ulcers appear, and the condition becomes worse. — DR. BIENFAIT, Liege.

Further serious disturbances of the digestive organs are found not infrequently among children, consequent upon the use of alcohol; but it is still more common to find slight digestive troubles noticeably increased by giving children alcohol to cure them. — ADOLF FRICK, M.D., Zurich.

Sir Henry Thompson, in a recent work on *Diet in Relation to Health*, gives the result of some personal experience in the use of alcohol with meals. Thirty-two years ago, at the age of fifty-two, he gave up the use of alcohol. Five or six years ago, for the sake of the experiment, he tried the effect of a claret glass of good wine at dinner every day for two months. Sick headaches and pains in the joints, from which he had suffered in early life, came back until he again abstained. After abandoning alcohol the joints gradually lost their stiffness and ultimately became as supple and mobile as they were in youth and continue absolutely so to this day. Dr. Thompson says he is not an exception, and he claims that a large class of active men possess a more or less similar temperament.

184. Effect of Alcohol on the Liver. When alcohol is taken up by the blood vessels of the stomach, it is carried directly to the liver, and filtered through this largest and most important organ before it reaches the heart. This, as we shall learn, is a part of the portal circulation (Sec. 210). Hence the poisonous effects of alcohol are strongly marked in the liver, especially among hard drinkers.

The blood vessels of the liver are overworked, and the capillaries engorged with blood. This causes, first, an enlargement of the liver, and then a shriveling of the substance of the organ, together with a rough and bunchy surface.

185. The Effect of Tobacco on Digestion. The use of tobacco, either in smoking or chewing, causes the glands of the mouth to secrete an unnatural amount of saliva; this, in time, weakens them and causes dryness of the throat. It may also interfere with digestion. Very frequently smoking leads to indigestion, which can only be cured by abandoning tobacco. Physicians meet with numerous cases of dyspepsia caused by the use of tobacco in some one of its forms.[1]

186. Smoking Cigarettes. Cigarettes may seriously impair general nutrition, causing loss of appetite, fullness of the stomach, nausea, vomiting, and dyspepsia. In many cases so marked are these symptoms of impaired nutrition that they produce a typical condition known as "cigarette cachexia."

[1] One of the more common effects of absorption of tobacco products is to impair the appetite and weaken digestion. — H. NEWELL MARTIN, M.D.

QUESTIONS ON THE TEXT

1. What, in a general way, is the object of digestion? 2. What is the alimentary canal? 3. Mention the various parts of the alimentary canal. 4. What takes place in the mouth? 5. Describe the process of chewing, or mastication. 6. Describe the structure of the teeth. 7. Mention the number and situation of the teeth, giving the name of each. 8. What are the salivary glands? 9. What is saliva, and what is its action? 10. What is meant by secretion and excretion?

11. Describe the process of swallowing food. 12. What is the epiglottis, and what useful purpose does it serve? 13. Explain the action of the gullet, or food pipe. 14. Describe the stomach. 15. What happens when the food reaches the stomach? 16. What is gastric juice, and how is it secreted? 17. Describe the action of the gastric juice. 18. Describe the small intestine. 19. What is the liver? 20. How does bile help in digestion?

21. What is pancreatic juice, and what is its action? 22. Describe, in a general way, the process of absorption. 23. What part do the lacteals play in the process of absorption? 24. What is the thoracic duct, and what is its use? 25. What are the lymphatics, and what work do they do? 26. Describe the spleen and other ductless glands. 27. Describe absorption by the blood vessels. 28. What is the large intestine and what purpose does it serve? 29. Upon what does the required quantity of food depend? 30. What are some of the ill effects of eating too much?

31. What should guide us as to what we should eat? 32. Describe in full when we should eat. 33. What can you say about the time to eat? 34. Mention other hints about eating. 35. Give some hints about the care of the teeth. 36. What are some of the effects of alcoholic liquors upon the stomach? 37. What are some of the effects of the long-continued use of alcohol upon the structure of the stomach? 38. What is the effect of alcohol on the liver? 39. Describe the effect of tobacco on digestion. 40. What is the effect of smoking cigarettes on digestion?

CHAPTER VII

THE CIRCULATION OF THE BLOOD

187. The Use of Blood. Every child knows that if he cuts his finger, or even pricks it with a needle, the blood will flow. What is true of the finger is also true of every other part of the body, except the outermost layer of the skin, the hair, and the nails.

The tiny blood vessels go everywhere, through the muscles and nerves, over and within the brain, through every part of every bone,—the blood flows everywhere. Wherever it goes, the blood has something to bring to the tissues and something to carry away.

The blood, in its ceaseless round, not only brings new material for repair, but it also becomes a kind of sewer stream that carries waste matters to organs whose duty it is to cast them out of the body.

188. Properties of Blood. The **blood** is a red, somewhat sticky fluid, thicker than water. It has a peculiar smell and a saltish taste. If we look at a small drop of freshly drawn blood under a microscope, we shall see that it is not so simple as it looks. It consists of fluid of a light straw color, called the **plasma,** and an enormous number of little bodies called **corpuscles,** floating in the liquid. These corpuscles are of two kinds, red and white.

189. Why the Blood looks Red. The red color of the blood is due to millions of little **red corpuscles** which float

about in the plasma. In the same way, a clear white glass bottle filled with red beads and water would look uniformly red at a short distance. There are about five hundred of the red corpuscles to one of the **white corpuscles.**

The red corpuscles contain iron combined with proteid. The red substance thus formed combines readily with oxygen and makes the blood scarlet.

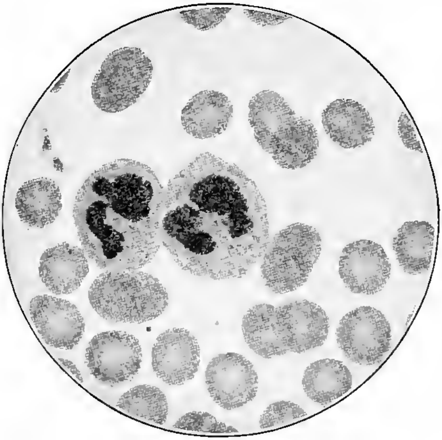

FIG. 82. Human Blood Corpuscles, as seen under the Microscope.
Magnified 1000 diameters.
The dark circular disks are the red corpuscles. Near the center two white corpuscles are seen, with their nuclei stained so that they look black.

Experiment 38. *To illustrate in a general way that blood is really a mass of red bodies which give the red color to the fluid in which they float.* Fill a clean white glass bottle two thirds full of little red beads, and then fill the bottle full of water. At a short distance the bottle appears to be filled with a uniformly red liquid.

190. The Red Corpuscles. In shape the **red corpuscles** are circular disks, resembling somewhat pieces of money. Their form is not unlike that of an india-rubber air cushion when blown up with air. They are not hard, but are like tiny pieces of red jelly. They are so elastic that they can squeeze through narrow places and then at once return to their own shape.

The red corpuscles are so very small that, if we had fingers delicate enough to handle them, we could place

some fifty thousand of them on the head of a pin. It is said that some five million of them will float round in a single drop of blood. If placed in a row side by side, it would take about thirty-two hundred of them to measure one inch. Under the microscope, the sides of these disks stick to one another in rolls, like so many coins.

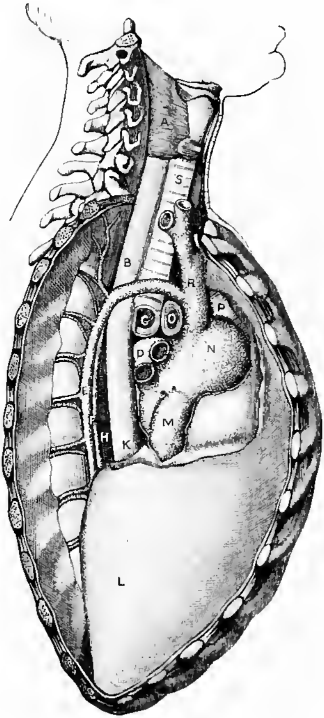

FIG. 83. Lateral Section of the Right Chest, showing the Relative Position of the Heart and its Great Vessels, the Œsophagus and the Trachea.

A, a muscle which aids in pushing the food down the œsophagus; *B*, œsophagus; *C*, section of the right bronchus; *D*, two right pulmonary veins; *E*, great azygos vein crossing œsophagus to empty into the superior vena cava; *F*, thoracic duct; *H*, thoracic aorta; *K*, lower portion of œsophagus passing through the diaphragm; *L*, diaphragm as it appears in sectional view, enveloping the heart; *M*, inferior vena cava, passing through diaphragm and emptying into right auricle; *N*, right auricle; *O*, section of right branch of the pulmonary artery; *P*, aorta; *R*, superior vena cava; *S*, trachea.

191. The Work done by the Red Corpuscles. The red corpuscles absorb oxygen in the lungs and carry it to the various tissues of the body, which are greedy for it. Night or day, whether we are asleep or awake, millions of these

tiny oxygen-carriers are as busy as bees, swirling through the blood vessels.

The blood has been beautifully called "the river of life." The red corpuscles may be compared to a countless fleet of little boats which are constantly floating along in this river.

192. The White Corpuscles. The **white corpuscles** are slightly larger than the red, and are not flattened. They may sometimes be kept alive under the microscope, and may be seen rolling and tumbling about. At one time they are round like a ball, and of such a size that it would take about twenty-five hundred of them to measure one inch. Shortly afterwards, however, they change this form and become pear shaped, three sided, and so on, in endless variety (Fig. 82).

The white corpuscles serve as a kind of scavenger for the body. They creep out of the blood vessels into the tissues and there pick up tiny bits of foreign substances. These corpuscles seem to be warrior cells, forever fighting against the invasion of bacteria.

Experiment 39. *To show the blood corpuscles.* Place a small drop of blood (easily obtained by pricking the finger with a needle) upon a clean slip of glass and cover with thin glass, such as is ordinarily used for microscopic purposes. The blood thus spread out into a film may be readily examined with a moderately powerful microscope. At first the red corpuscles will be seen as pale, disklike bodies floating in the clear fluid. Soon they will be observed to stick to each other by their concave faces, so as to form rows. Here and there a white corpuscle may be seen among the red ones (Fig. 82).

193. The Clotting of Blood. If a basin of fresh blood is allowed to stand for a short time, it will separate into two parts: one, a sticky, jellylike mass, called the **clot**, settles to the bottom; the other, a straw-colored, watery fluid,

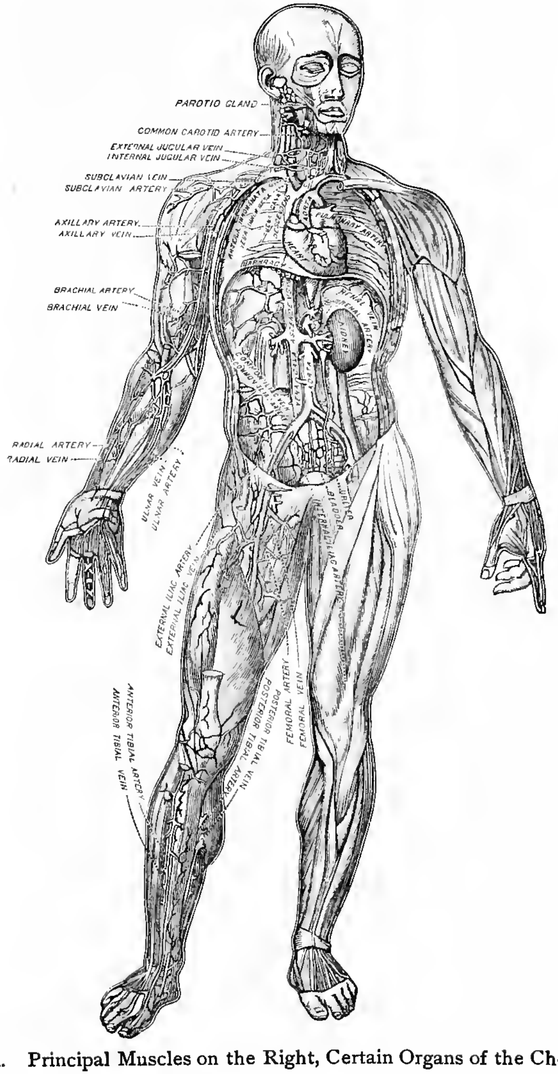

FIG. 84. Principal Muscles on the Right, Certain Organs of the Chest and Abdomen, and the Larger Blood Vessels on the Left.

called the **serum**, remains at the top. This change of the blood, after it is drawn from the body, into a jelly-like, semisolid mass, is called the **clotting**, or the **coagulation**, of the blood.

The watery part, or **serum** as it is called, is blood from which the corpuscles have been removed by the process of clotting. It is largely made up of water in which albumin is dissolved.

The **clot** consists mainly of two substances, — the corpuscles and a network of white, tough, fibrous threads, called **fibrin**. The clotting of blood is not yet fully understood, but it is thought to be due in part to the formation of this fibrin. The corpuscles get snarled in the meshes of the fibrin, and thus the clot is formed.

194. Why the Clotting of Blood is Important. The fact that blood clots when shed is one of its most striking properties. It is of the most vital importance. When a person receives a severe wound he would bleed to death unless clotting set in. Nature in this way plugs up the wound with clots of blood and prevents too much bleeding. Blood does not clot within the healthy vessels. It may do so in certain diseased conditions.[1]

Experiment 40. Put two or three drops of fresh blood on the bottom of a little white butter plate. Place the plate in a saucer which has a little water in it and cover it with an inverted goblet. Take off the cover in five minutes, and the drop has set into a jellylike mass. In half an hour a little clot will be seen in the watery serum.

[1] Thus, in those who suffer from enlarged or varicose veins, a clot may sometimes form in the veins of the leg. Snake poison may act to cause the blood to clot within the vessels. In some very rare cases there are people born in whom the blood has little or no power of clotting. These are known as "bleeders," and with them a slight cut on the finger or even a pin scratch may prove a serious matter, owing to the loss of blood.

195. General Plan of Circulation. Since all the tissues stand in such constant need of blood, there must be some special machinery by which this "river of life" is made to keep up its constant flow through every nook of the body. Let us now begin the study of this apparatus.

In the first place, there is in the chest a little pump called the **heart**, from which tubes are distributed to all parts of the body.

One set of tubes, called **arteries**, carries the blood *from* the heart.

Another set of tubes, called **veins**, brings the blood back *to* the heart.

This continued flow of blood through the body, to and from the heart, is called the **circulation of the blood.**

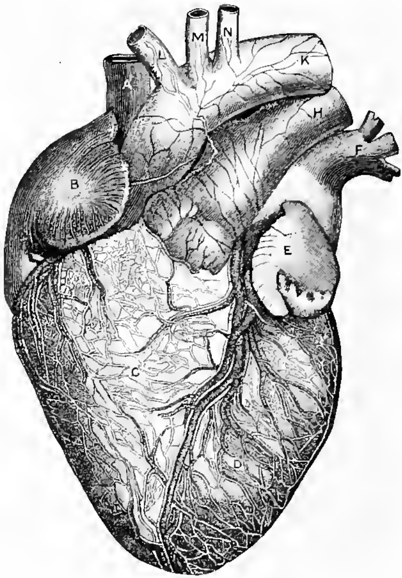

FIG. 85. Anterior View of the Heart.

A, superior vena cava; *B*, right auricle; *C*, right ventricle; *D*, left ventricle; *E*, left auricle; *F*, pulmonary vein; *H*, pulmonary artery; *K*, aorta; *L*, right subclavian artery; *M*, right common carotid artery; *N*, left common carotid artery.

196. The Circulation compared to the Water Service of a City. The way in which blood is made to flow through vessels of the body may be compared in a general way to the manner in which water is supplied to a city. The heart is the pumping engine which forces the blood into the main pipes for the supply of the several districts.

As through a city the great water mains branch and subdivide into smaller pipes for the supply of districts, streets, houses, and rooms, so in the body the blood vessels divide over and over again to furnish blood to the smallest organs and the most remote parts of the tissues. The parallel ends here. The water supplied to the city does not return to the pumping station, whereas the blood returns to the heart.

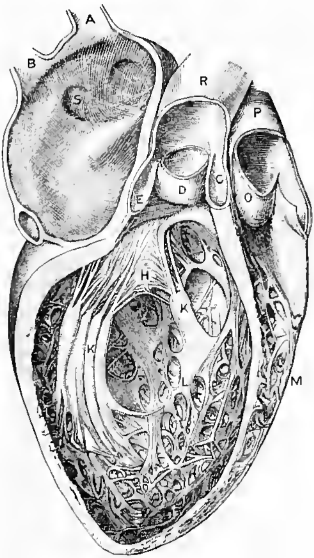

FIG. 86. Cavities of the Heart.

A, *B*, right pulmonary veins; *S*, openings of the left pulmonary veins; *E*, *D*, *C*, aortic valves; *R*, aorta; *P*, pulmonary artery; *O*, pulmonic valves; *H*, mitral valve; *K*, columnæ carneæ; *M*, right ventricular cavity.

When the blood has been pumped through every part of the body, and has given to it the food which it needs, it receives from the tissues certain waste matters, the result of wear and tear. The blood is now no longer fit for nourishment, but is more like a kind of sewer stream laden with waste matters. These, in due time, are brought to certain organs, as the lungs, the skin, and the kidneys, and cast out of the body.

197. The Heart. The heart is hollow and muscular, somewhat like a pear in shape. It is hung almost in the center of the chest, above the diaphragm, and is partly overlapped by the lungs. It is about the size of the closed fist of the person to whom it belongs.

The apex of the heart beats against the chest wall between the fifth and sixth ribs, about an inch and a half to the left of the middle line of the body.

198. The Pericardium. The heart lies within a strong, fibrous membrane forming a kind of bag or purse called the **pericardium.** This bag is really double, with two layers, one over the other. The inner layer closely covers the surface of the heart and is reflected upon itself to form a sack without an opening.

Place your hand in a stocking which has the foot turned inwards, and your hand will be covered by a double coat somewhat as your heart is by its double bag.[1] Between the two layers of the pericardium there is a small quantity of clear fluid which permits the parts to move one upon the other with little friction.

199. The Chambers of the Heart. The heart has a muscular partition running down its center from top to bottom, separating the right side from the left. Each of these sides has two hollow **chambers** or **cavities**: an upper one called an **auricle,** from the fancied resemblance of one corner to the ear of a dog; the other and lower one called a **ventricle.** Hence there are two upper chambers called **auricles,** and two lower chambers called **ventricles.**

The heart is a muscle; hence it can contract. When each of its chambers contracts, blood is forced to flow into the next chamber or a blood vessel, as the case may be. The walls of the ventricles are stouter and stronger than

[1] We must remember, however, that the leg of the stocking is open at the end while the pericardium is closed. We may think of the pericardium shielding the heart somewhat as the leather case of a football protects the bladder within it. Again, the pericardium is arranged about the heart as a boy's toboggan cap covers his head.

those of the auricles, and those of the left ventricle are much stouter than those of the right ventricle.

The right auricle opens into the right ventricle, and the left auricle into the left ventricle; but there is no connection between the right and left cavities of the heart.

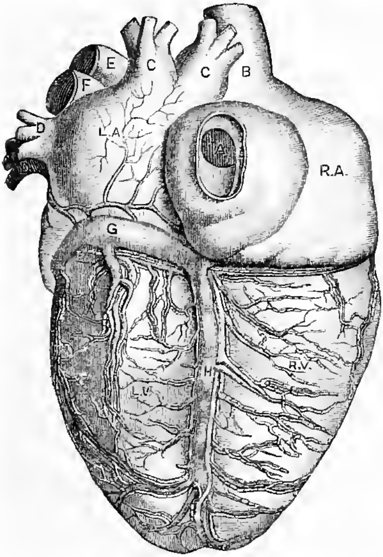

FIG. 87. Posterior View of the Heart.

L.A., left auricle; *R.A.*, right auricle; *L.V.*, left ventricle; *R.V.*, right ventricle; *A*, opening of the inferior vena cava; *B*, superior vena cava; *C*, right pulmonary veins; *D*, left pulmonary veins; *E*, aorta; *F*, left branch of pulmonary artery; *G*, great cardiac vein; *H*, middle cardiac vein. The cardiac lymphatics which follow the course of the cardiac veins are also shown.

200. The Valves of the Heart. The openings between the auricles and ventricles are guarded by flaps of membrane, or little swing doors, called **valves.**

These valve flaps may be roughly compared to folding doors or gates, which, by opening only one way, allow the blood to flow in that direction and prevent its flowing in any other.

The valve on the right side of the heart is called the three-pointed, or **tricuspid,** valve.

The valve on the left looks somewhat like a bishop's miter; hence it is called the **mitral** valve.

These valves fall back to let the blood flow from the auricles into the ventricles, but float up with the blood so

as to prevent the return of the blood into the auricles. The valves are prevented from floating over into the auricles by cords which tie them to the ventricles. These cords may be drawn tight by the contraction of the little muscles in the wall of the ventricles to which they are attached.

Between the ventricles and the arteries are the half-moon shaped, or **semilunar**, valves.

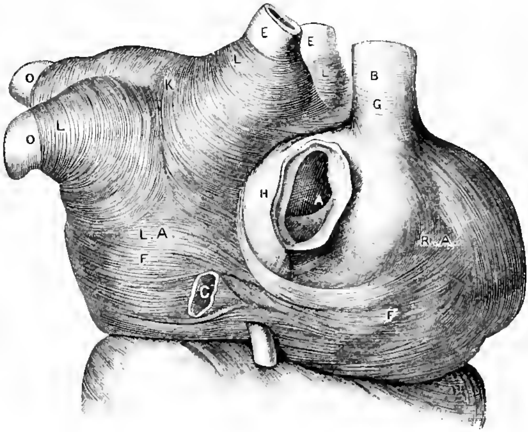

FIG. 88. Muscular Fibers of the Auricles.

L.A., left auricle; *R.A.*, right auricle; *A*, opening of the inferior vena cava; *B*, superior vena cava; *C*, cardiac vein of right auricle laid open; *D*, left pulmonary veins; *E*, right pulmonary veins; *F*, muscular fibers surrounding the openings between the left auricle and left ventricle, and the right auricle and right ventricle; *G*, *H*, *K*, and *L*, muscular fibers surrounding the great veins of the heart.

201. The Work of the Heart. The heart is a wonderfully busy machine, pumping away without getting tired, night and day for eighty years or more, perhaps, at the rate of seventy strokes every minute, over forty-two hundred times every hour, and nearly thirty-seven million beats every year. At each

stroke the ventricles pump about six ounces, or nearly fifty teaspoonfuls, of blood. About eighteen pounds of blood are moved every minute, or twelve tons every day.

It is calculated that the total amount of daily work done by the heart can be represented by what a man of average weight, about one hundred and fifty pounds, would do in running up a flight of forty steps forty times. While the cavities are filling with blood, and its muscles are relaxed, the heart has a brief rest; otherwise, it could not keep up its patient and tireless pumping of over four thousand tons of blood every year, from birth to death.[1]

202. The Blood Vessels that enter and leave the Heart. The **aorta**, the largest artery in the body, springs from the left ventricle. It carries the bright, pure blood from the heart to all parts of the body.

Four **pulmonary veins** open into the left auricle. Two of these veins come from the right lung and two from the left lung. They bring back to the heart the blood which has been combined with oxygen in the lungs.

Two of the largest veins in the body, called the **superior vena cava** and the **inferior vena cava**, open into the right auricle. These great veins pour into the right auricle the dark blood which has been collected in various parts of the body by the smaller veins (Fig. 95).

The **pulmonary artery** springs from the right ventricle. Soon after leaving the heart, it splits into two pipes; one goes to the right lung, the other to the left lung. This artery carries from the heart to the lungs the dark, impure blood which has been brought to it by the great veins. Its entrance is guarded by the three semilunar valves.

[1] It should be remembered that the two auricles contract at the same time and then the two ventricles. Then comes a pause, or state of rest, after which the auricles and ventricles contract in the same order as before.

203. The Aorta and its Great Branches. Branches of the **aorta** carry blood from the heart to the tissues. They are called **arteries.** After leaving the heart the aorta rises towards the neck, but soon curves downwards to form the arch of the aorta. This great tube passes between the lungs to the back, then runs down along the spine through the diaphragm.

In the abdomen it divides into two branches, one of which goes to each lower limb.

Branches springing from the arch of the aorta supply the head and the arms.

While the aorta is passing down the spine it gives off branches to nourish the lungs and the important organs of the abdomen.

FIG. 89.

Showing the carotid artery and jugular vein on the right side, with some of their main branches; also some large nerve trunks.

Experiment 41. *To illustrate how the heart pumps blood.* Sink the suction end of a bulb syringe into water. Press the bulb. As the bulb expands, it fills with water; as we press it again, a valve prevents the water from flowing back, and it is driven out in a jet along the main pipe. The suction pipe represents the veins; the bulb, the heart; and the tube end, the arteries.

204. The Veins. The **veins** are the return pipes that bring the blood back to the heart. They generally lie near the surface of the body, just beneath the skin. We may see them in almost any part of the body. Unlike the arteries, which gradually grow smaller and smaller, the veins, starting from the capillaries, grow larger and larger.

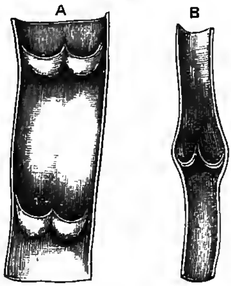

FIG. 90.

A, part of a vein laid open, with two pairs of valves; *B*, longitudinal section of a vein, showing the valves closed.

The veins of the legs pass upwards, becoming gradually larger by the addition of other branches in the abdomen, until at last all the united branches are joined in one great vein, which empties into the right auricle of the heart (Sec. 202).

The venous blood from the head and the arms empties into the right auricle by another large vein.

As we have learned, the four **pulmonary veins** carry the arterial blood from the lungs to the left auricle (Sec. 202).

The veins are abundantly supplied with little pouch-like folds or pockets which act as **valves** to prevent the backward flow of the blood. If we press the fingers along one of the veins in the arm, towards the hand, we shall see a number of little knots or swellings here and there along the vein. These indicate the position of the valves.

The blood thus forced back fills the little pockets in the vein. Take away the finger and the knots will at once disappear, because the blood is left free to flow towards the heart.

Experiment 42. Grasp the left wrist tightly with the thumb and two fingers of the right hand. Note the little knots or swellings in the veins on the back of the hand, caused by checking the flow of the venous blood towards the heart. These swellings show the position of the valves of the veins.

205. The Capillaries. Between the ends of the smallest arteries and the beginnings of the tiniest veins is a very close network, like the finest lace, with the minutest little tubes for threads. These little tubes or threadlike vessels are called **capillaries.**

In reality the capillaries are as much smaller than threads as the smallest threads are smaller than cables. So close

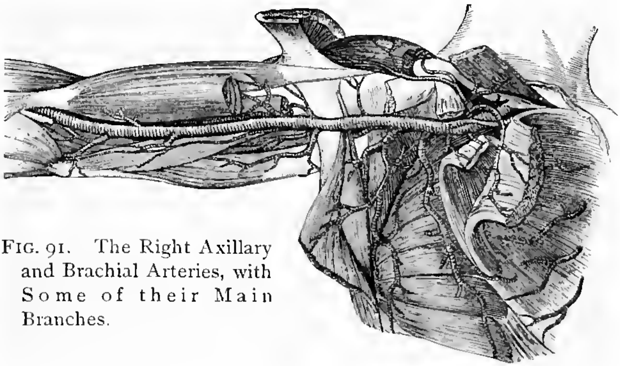

FIG. 91. The Right Axillary and Brachial Arteries, with Some of their Main Branches.

set are these tiny vessels that we cannot prick any part of the skin, even with the finest needle, without wounding many of them and drawing blood. They are so small that three thousand of them placed side by side would not, in their united width, measure more than one inch.

206. The Interchange between the Blood in the Capillaries and the Lymph in the Tissues. The capillaries are closed vessels. The space between the walls of the capillaries

and the cells of the tissues is filled with a clear, watery fluid known as **lymph.**

As the blood flows along the capillaries, certain parts of the plasma of the blood filter through their walls into the lymph, and certain parts of the lymph filter in the opposite direction through the walls of the capillaries and mingle with the blood current. A constant interchange of material is thus going on between the lymph which bathes the tissues and the blood in the capillaries.

In brief, **the lymph acts as a medium of exchange between the blood and the tissues.**

207. The General Course of Circulation. We are now ready to study the circulation as a whole, tracing the course of the blood from a certain point until it returns to the same point. We may conveniently begin with the portion of blood contained at any moment in the right auricle.

We may perhaps better understand the general course of circulation if we subdivide it into two parts: the **pulmonary** circulation, or circulation in the lungs, and the **systemic,** or greater, circulation.

We must keep clearly in mind, however, that there is but a single circulation in the body.

208. The Pulmonary, or Lesser, Circulation. Two large veins are busily filling the right auricle with dark (venous) blood, collected from all parts of the body. When the auricle contracts, the blood cannot get back into the great veins because it is flushed forward by the great volume of blood behind it. The door opening into the right ventricle lies open, and the blood flows through it until it is full.

The ventricle now begins to contract; the tricuspid valve at once closes and thus prevents the backward flow of

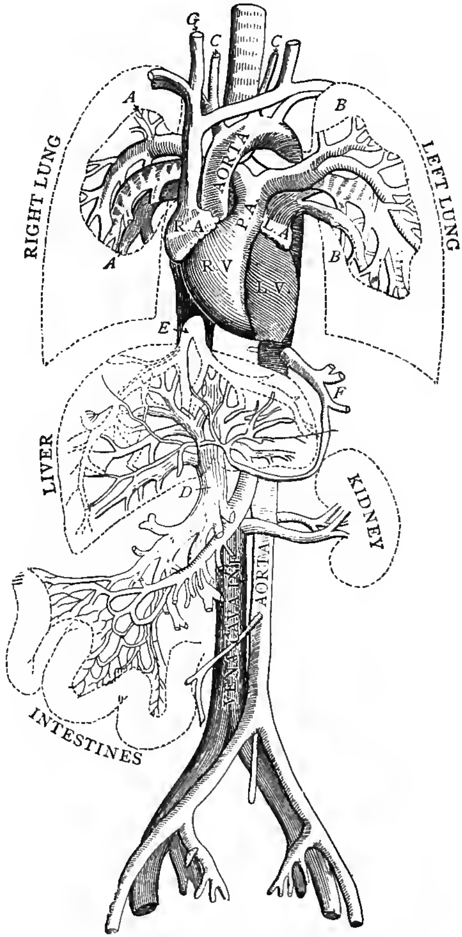

FIG. 92. Diagram of the Circulation of Blood.

R.A., right auricle; *L.A.*, left auricle; *R.V.*, right ventricle; *L.V.*, left ventricle; *P.A.*, pulmonary artery; *A*, pulmonary artery and vein of right lung; *B*, pulmonary artery and vein of left lung; *C*, carotid artery to head, showing branch of left subclavian artery; *D*, portal vein; *E*, hepatic vein; *F*, hepatic artery; *G*, superior vena cava, bringing blood from head and upper limbs to right auricle.

blood. The blood is driven into the pulmonary artery past the semilunar valves.

The pulmonary artery carries the blood to the lungs. The dark, impure blood is driven along smaller and smaller vessels until it reaches the capillaries of the lungs. Here it is, as it were, spread out to be purified. Exposed to the oxygen of the air, the blood gives up carbon dioxide and other impurities and loses its purple color. It takes up a great deal of the oxygen of the air in exchange, and in a purified state and of a bright scarlet color, it comes back to the heart by the four pulmonary veins which pour it into the left auricle.

209. The Systemic, or Greater, Circulation. From the left auricle the blood is forced past the mitral valve into the left ventricle. As soon as the left ventricle is full it begins to contract. The mitral valve at once closes and blocks up the passage into the left auricle, and the blood has no other way open but past the semilunar valves[1] into the aorta.

The aorta and its branches, as we already know, distribute the blood through every tissue of the body. From the tissues it is again returned by the veins to the right auricle of the heart, and thus the round of circulation is continually kept up.

Experiment 43. *To illustrate some of the phenomena of circulation.* Attach a piece of rubber tube about six or eight feet long to the delivery end of a common rubber bulb syringe.

To represent in a very crude way the resistance made by the capillaries to the flow of blood, slip the large end of a common glass medicine dropper into the outer end of the rubber tube. This dropper has one end tapered to a fine point.

[1] The entrance to the aorta is guarded by three semilunar valves similar to those at the entrance of the pulmonary artery.

Place the syringe flat, without kinks or bends, on a desk or table. Press the bulb slowly and regularly. The water is thus pumped into the tube in an intermittent manner, and yet it is forced out of the tapering end of the glass tube in a steady flow.

FIG. 93. William Harvey demonstrating the Circulation of Blood to King Charles the First of England.[1]

210. The Portal Circulation. The blood which is brought to the capillaries of the stomach, intestines, spleen, and pancreas takes a roundabout course to get back to the heart.

[1] William Harvey was a famous English physician who discovered the circulation of the blood, nearly three hundred years ago. This fine picture represents the king as witnessing the dissection of a doe, of which he had placed many at Harvey's disposal while the great physician was making his investigations concerning the circulation of the blood.

The picture is used by the kind permission of William Wood & Co., publishers.

It is collected into veins which unite into a single trunk, called the **portal vein**, which enters the liver.

The blood, now mingling with that brought to the liver by the **hepatic artery**, is carried by small veins which at length unite into a large trunk, the **hepatic vein.** This vein pours the blood into the inferior vena cava, which carries it to the right auricle (Fig. 74).

This loop, as we may call it, on the systemic circulation is often called the **portal circulation.**

Experiment 44. *To show the circulation in the web of a frog's foot.*[1] To show the circulation in a frog's foot it is necessary to hold the frog in place. Take a piece of soft wood about six inches long and three wide. At about two inches from one end cut a hole half an inch in diameter and cover it with a glass slide, which should be let into the wood, level with the surface. Then wrap the frog in a damp cheese cloth, leaving one foot exposed. Next, fasten a piece of thread to each of the

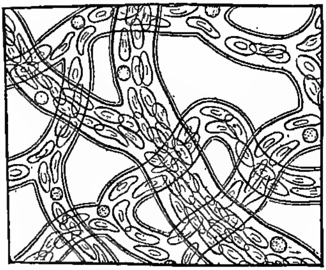

FIG. 94.

Showing how the circulation of blood in the web of a frog's foot looks as seen under the microscope.

[1] The student may find it easier to manage a tadpole than a frog. The following experiment showing the circulation of the blood in the tail of a tadpole is taken from Peabody's *Laboratory Exercises in Anatomy and Physiology*, p. 56.

Cut a hole a half inch square near the end of a piece of thin board three inches long and one inch wide; glue a thin cover glass over the hole. Cover the rest of the piece of wood with absorbent cotton soaked in water. Lay a live tadpole on the cotton, placing the tip of the tail on the cover glass. Lay a cover glass on top of the tail, and fasten cheese cloth over the animal to keep it in place. Keep a plentiful supply of moisture about the animal by allowing the end of the strip of cloth to dip into a dish of water. Examine the tip of the tail with a compound microscope magnifying about seventy-five diameters.

two longest toes, but not tight enough to stop the circulation or hurt the frog.

Fasten the frog upon the board in such a way that the foot will just come over the glass slide. Pull carefully the thread tied to the toes, so as to spread out the web over the glass. Fasten the threads by drawing them into slits cut in the sides of the board. The board should now be fixed by elastic bands, or by any other convenient means, upon the stage of the microscope. The web should be occasionally moistened with water. Care should be taken not to occasion any pain to the frog. The circulation of blood thus shown is a wonderful sight, and never to be forgotten.

211. The Beat, or Impulse, of the Heart. If the hand be laid flat over the chest wall on the left side, a peculiar throbbing will be felt. This throbbing movement is known as the **beat**, or **impulse**, of the heart. It is due to the hard, tense part of the ventricles coming in contact with the chest wall at the moment when the hardening of the ventricles takes place. The heart beats are unusually strong during active bodily exertion and under mental excitement.

212. The Sounds of the Heart. If we place our ear against a friend's chest, over the region of the heart, we hear two distinct sounds. These sounds may be fairly imitated by pronouncing the syllables *lub*, *dup*. The first is a dull, muffled sound, known as the "first sound," followed at once by a shorter and sharper sound, known as the "second sound" of the heart.[1]

213. The Pulse. If the finger be placed over an artery which lies near the surface of the body, like the radial

[1] The precise cause of the first sound is not certainly known, but the second sound is, without doubt, caused by the tension of the semilunar valves of the pulmonary artery and the aorta at the moment when the contraction of the ventricles is completed. If these valves are diseased and do not shut properly, a blowing sound or murmur will be produced. Thus, by listening to the sounds of the heart a doctor may be able to tell whether the valves are out of order.

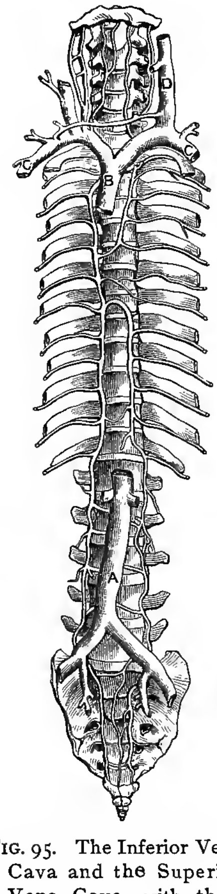

FIG. 95. The Inferior Vena Cava and the Superior Vena Cava, with their Connecting Veins.

artery, for instance, near the wrist, or the temporal artery, just over the temples, a slight throbbing pressure on the finger will be felt. This pressure, which comes and goes at regular intervals, corresponds to the beats of the heart. It is called the **pulse.**

Let us learn the reason for it. When the left ventricle contracts, the blood is forced into the arteries and their walls are suddenly distended. This wave of distension, or pulse, can be felt in all the large arteries.

In a grown person the pulse beats about seventy-two times a minute. In children the pulse is quicker than in adults. In old age the pulse is slower than in adult life.

By feeling the pulse with a skilled touch it can be told whether the heart beat is too fast or too slow, strong or weak, regular or irregular. Thus, the pulse is a most important guide to the doctor, for it may tell him many things about the condition of his patient.

A, inferior vena cava, cut off just above the hepatic veins: *B*, superior vena cava, cut off just below the junction of the innominate veins; *C*, right and left innominate veins; *D*, left internal jugular vein. The veins, known as *azygos*, with some of their main branches, are shown. These veins connect the superior vena cava and the inferior vena cava.

Experiment 45. *To illustrate the effect of muscular exercise in quickening the pulse.* Run a short distance. Count the pulse both before and after. Note the effect of running upon the rate.

Experiment 46. *To hear the sounds of the heart.* Borrow a stethoscope from some physician and listen to the heart beat of a friend. Note the sounds of your own heart in the same way.

Experiment 47. *To find the pulse.* Grasp the wrist of a friend, pressing with three fingers over the artery, and note the pulse. Press three fingers over the radius in your own wrist, and note the pulse.

Count by a watch the rate of your pulse per minute, and do the same with a friend's pulse. Compare its character with your own.

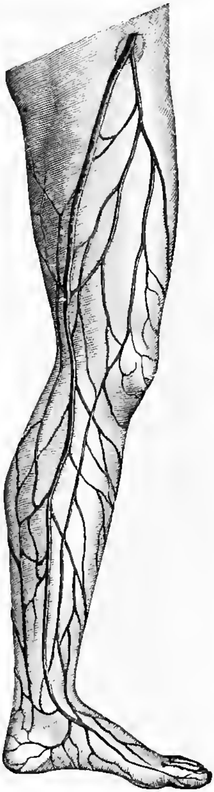

FIG. 96. The Internal, or Long Saphenous, Vein of the Left Leg.

214. How Alcohol gets into the Blood. Alcohol passes into the blood by two distinct routes. When an alcoholic liquor is taken into the stomach, some of it at once soaks through the coats of the tiny blood vessels with which the inner wall of the stomach is covered, and is carried into the blood current by the portal circulation.

Alcohol is also taken up by the lacteals, and is emptied by them into the blood current by way of the thoracic duct. Now, although alcohol goes to the heart to be sent to every part of the body in this roundabout way

through the liver, it takes only a moment or two for it to get into the main blood stream.

A glass of strong drink soon "goes to the head," as many people know, showing that its effects are rapidly produced in the cells of the brain. The rapidity of this absorption depends upon the kind of liquor and whether the stomach is empty or full.

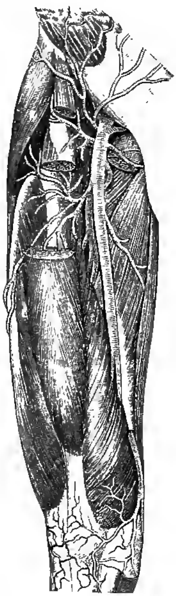

FIG. 97. The Femoral Artery of Right Leg.

215. The Effect of Alcohol upon the Blood Vessels. The effect of alcohol on the circulation is shown by its action on the nervous system. The muscular walls of the arteries are made larger or smaller by means of tiny nerves which regulate their size.

Even a moderate amount of alcohol disorders or paralyzes for a time the action of those nerves which control the blood vessels. The muscular fibers of the arteries are relaxed, the blood distends them, and the skin appears redder and seems warmer than before the alcohol was taken. This feeling of warmth is due to the heat that is forced to the surface of the body by the blood. This also explains the flushed face and warm glow which so often mark the appearance of moderate drinkers.

216. Further Effect of Alcohol upon the Blood Vessels. Under the influence of alcohol, the walls of the blood vessels, especially the capillaries, after a time become permanently dilated. This chronic enlargement of the arterial

twigs is often seen in the red-streaked nose, the red or purplish face, and the bloodshot eyes of those who have indulged in strong drink for a long time.

The continued use of alcoholic beverages may gradually bring about a change in the muscular walls of the arteries. In some cases there is an undue deposit of fat cells and other morbid products. The weakened and stiffened arterial walls now gradually lose their elasticity so that they are less able to do their part in the circulation of the blood. At last the walls of the arteries become weakened, especially in the arteries of the brain. Owing to some unusual strain of work, or through mental excitement, the walls of the enfeebled blood vessels of the brain may burst and cause death from apoplexy.[1]

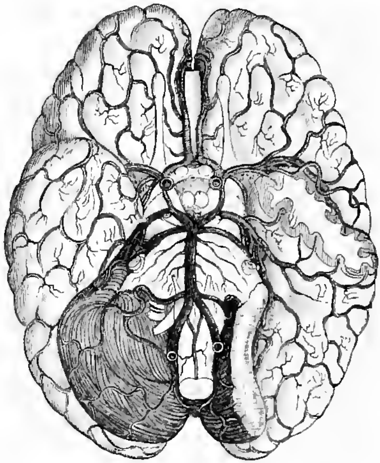

FIG. 98. Arteries and their Branches at the Base of the Brain.

217. Effect of Alcohol upon the Structure of the Heart. The long-continued use of strong drink may produce

[1] The primary effects of a moderate dose of diluted alcohol, as a glass of whisky and water, on one unaccustomed to it, are to cause dilation of the blood vessels of the skin, indicated by the flushed face, a more rapid beat of the heart, and nervous excitement exhibited by talkativeness.

Blood containing two and one-half parts to one thousand of absolute alcohol almost invariably diminishes within a minute the work done by the heart. — H. NEWELL MARTIN, M.D.

important changes in the structure of the heart. As with the walls of the arteries, so with the heart: the prolonged use of alcohol may cause a deposit of fatty tissue in place of the muscular fibers.

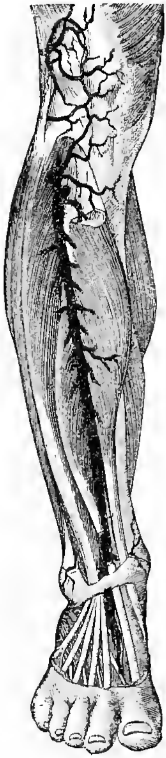

FIG. 99. Artery in the Front of the Right Leg.

This diseased condition, known as "fatty degeneration," may seriously interfere with the heart's power of contraction. The walls may become much thicker and the ventricles smaller from this deposit of fat, and thus the overtired organ may fail in its efforts to pump forward the blood which rushes in from the auricles.

Alcoholic excess may also cause an overgrowth of adipose tissue upon the surface of the heart which may seriously interfere with the normal cardiac action.

Again, the ventricles may become much too large, and from lack of proper elasticity may be unable to pump forward the blood. All these conditions are apt to cause the valves to lose their suppleness, and may cause death by what is known as sudden heart failure.

218. Effect of Tobacco upon the Heart. The nicotine of tobacco acts to partially paralyze the nerves that control the heart's action. Under its influence the movements of the heart are irregular, now feeble and fluttering, now thumping with apparently much force. Frequently there is severe pain about the heart, often dizziness with gasping breath, extreme pallor, and fainting.

While tobacco may cause a more or less injurious effect upon other organs of the body, it is upon the heart that it may work its most serious wrong. Upon this most important organ its effect is often to depress and paralyze. Especially does this apply to the young, whose bodies are not yet knit into the vigor of manhood.

219. Heart Disease caused by Tobacco. There are few conditions more distressing than the suffering produced by a palpitating heart. It is claimed by medical men that about one in every four tobacco users is subject, in some degree, to this disturbance. Test examinations of a large number of boys who had used cigarettes showed that only a very small percentage escaped cardiac trouble.

The condition of the pulse is a guide to this state of the heart. In this the physician reads plainly the existence of the "tobacco heart," an affection clearly recognized by the medical profession.

Many of the young men who made application to enlist during our war with Spain, in 1898, were rejected because the physical examination revealed a tobacco heart.

Of older tobacco users there are very few but have some warning of the effects of overindulgence in this narcotic. Generally they suffer more or less from the tobacco heart, and if the nervous system or the heart be naturally feeble, they suffer all the more speedily and intensely.[1]

[1] The irregularity in the heart's action, which tobacco causes, is one of its most conspicuous effects. Candidates, who are annually rejected for cardiac disturbances, have subsequently admitted the use of tobacco; the annual physical examination of cadets reveals a large number of irritable hearts — tobacco hearts — among boys. — Surgeon General U. S. Navy.

Tobacco, and especially cigarettes, being a depressant upon the heart, should be positively forbidden. — J. M. KEATING, M.D., on "Physical Development," in *Cyclopædia of the Diseases of Children.*

QUESTIONS ON THE TEXT

1. What are the two general uses of the blood? 2. State in a general way where the blood vessels are found. 3. Give some of the properties of blood. 4. Of what does blood consist, and why does it look red? 5. What simple experiment will illustrate in a general way why the blood seems uniformly red? 6. Describe the red corpuscles. 7. Of what use are the red corpuscles? 8. Describe the white corpuscles. 9. State briefly the use of the white corpuscles. 10. How does blood look when examined with the microscope?

11. What happens if blood is allowed to stand for a short time? 12. What is meant by the coagulation of the blood? 13. Describe the serum of the blood. 14. Of what is the clot composed? 15. Why is the clotting of blood important? 16. Describe briefly the apparatus concerned in the circulation of blood. 17. How may the blood circulation be compared to the water service of a city? 18. Describe the heart. 19. What is the pericardium? 20. In what simple way may the position of the pericardium be shown?

21. Describe the chambers, or cavities, of the heart. 22. What are the valves of the heart? 23. Describe the action of the various valves. 24. What can be said of the work done by the heart? 25. What is the aorta? 26. Describe the pulmonary veins. 27. Describe the pulmonary artery. 28. What are the two largest veins of the body, and what is their action? 29. Mention some of the main branches of the aorta. 30. What are veins?

31. What simple experiment will illustrate the action of the veins? 32. What are capillaries? 33. What interchange takes place between the blood and the lymph? 34. Into what two parts may the course of the circulation be subdivided? 35. Describe the pulmonary circulation. 36. Describe the systemic circulation. 37. What is meant by the portal circulation? 38. What is the beat, or impulse, of the heart? 39. What are the two sounds of the heart? 40. What is the pulse, and what may it indicate to the doctor?

41. How does alcohol get into the blood? 42. What is the effect of alcohol upon the blood vessels? 43. What is the effect of alcoholic excess upon the heart? 44. How does tobacco affect the heart? 45. Describe the so-called "tobacco heart."

CHAPTER VIII

BREATHING

220. The Act of Breathing. Night and day, without one minute's rest, from the first to the last moment of our lives, we are **breathing.** Most of the time we do not think anything about it. We eat, talk, work, and sleep; and all this time our breathing goes quietly on. We can hold our breath for a short time, yet after a few seconds we begin to feel uncomfortable.

221. The Object of Breathing. In studying food and blood, we have learned that without food and air the burning, or oxidation, which is slowly going on in our bodies all the time, would soon flag, and life would come to an end.

We have learned that the dark blood is sent to the lungs from the right ventricle and is returned to the left auricle as blood of a bright red color. The blood has got rid of part of its waste matter, and has taken up oxygen.

Hence, in **breathing** we have two objects in view: first, to give a fresh supply of oxygen to the blood; second, to get rid of carbon dioxide and other waste matter taken up from the tissues and brought to the lungs by the blood.

222. The Air Passages. The air is drawn into the lungs through the mouth, the nostrils, and the windpipe.

The **nostrils** are really the passageways for the air, and warm it somewhat before it passes into the windpipe, or trachea, on its way to the lungs.

The **windpipe** is a tube about four inches long, which is protected on the front and sides by stout rings of cartilage. But for these rings the windpipe would close with the slightest pressure and cut off our breath.

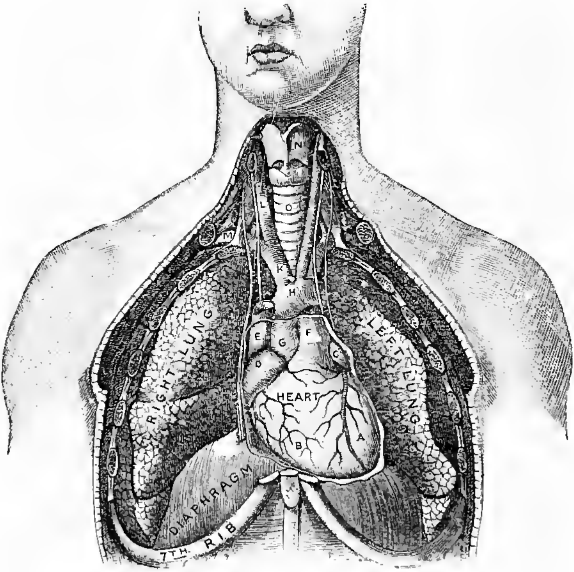

FIG. 100. Relative Position of the Lungs, the Heart, and Some of the Great Vessels belonging to the Latter.

A, left ventricle; *B*, right ventricle; *C*, left auricle; *D*, right auricle; *E*, superior vena cava; *F*, pulmonary artery; *G*, aorta; *H*, arch of the aorta; *K*, innominate artery; *L*, right common carotid artery; *M*, right subclavian artery; *N*, thyroid cartilage forming upper portion of the larynx; *O*, trachea.

The top of the windpipe is protected by a trapdoor known as the **epiglottis**. This little door, as we have learned, shuts tight when food is swallowed, and keeps the food out of the air passages; otherwise the food would go the wrong way, and cut short our breath (Sec. 153 and Fig. 69).

The upper part of the windpipe is a kind of box called the **larynx**, or organ of voice. In this box are the **vocal cords**. In some persons it is very prominent, and the front edge of it is commonly called "Adam's apple" (Figs. 100, 173, 174, and 175).

223. The Bronchial Tubes. The windpipe, after entering the chest, divides into two branches called **bronchi**, one to each lung. These again divide into smaller tubes called **bronchial tubes**.

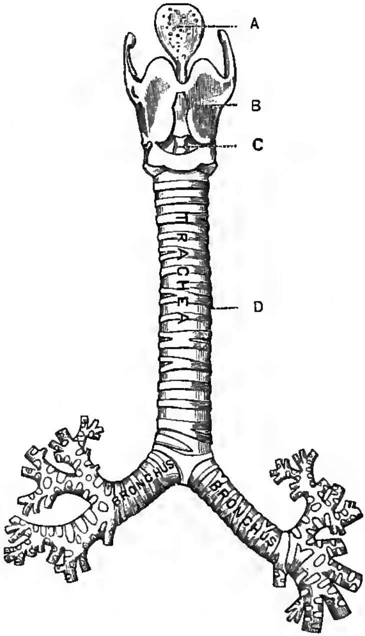

FIG. 101. Larynx, Trachea, and the Bronchi. (Front view.)

A, epiglottis; *B*, thyroid cartilage; *C*, crico-thyroid membrane, connecting with the cricoid cartilage below, all forming the larynx; *D*, rings of the trachea.

Each bronchial tube divides again into smaller branches, these again into smaller, and so on to the tiniest twigs many times smaller than the hairs of our head.

The numberless bronchial tubes pass to all parts of the lungs, and end finally in clusters of short, blind, and somewhat dilated pouches called **alveoli**. Each of these closed, dilated ends is divided into a number of air cavities or **air sacs**.

If we remember that all these tubes, great and small, are hollow, we may compare them to a short bush or tree

growing upside down in the chest, of which the windpipe is the trunk, the bronchial tubes are the branches, and the air cavities of the lungs are the leaves.

224. The Lungs. The **lungs** are two large, pinkish, spongy organs, which surround the heart and the large vessels, and fill up all the rest of the chest cavity. So light and spongy is their structure that a piece of a lung, unlike any other tissue, will float in water.

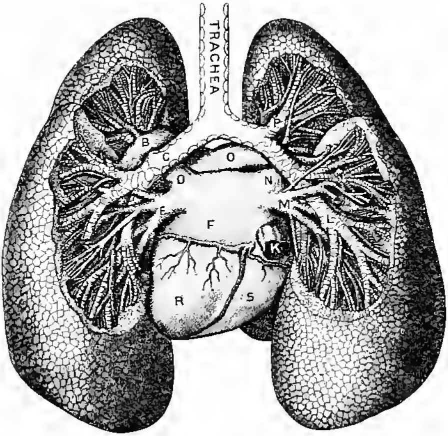

FIG. 102. The Lungs, with the Trachea, Bronchi, and Larger Bronchial Tubes exposed. (Posterior view.)

A, division of left bronchus to upper lobe; *B*, left branch of the pulmonary artery; *C*, left bronchus; *D*, left superior pulmonary vein; *E*, left inferior pulmonary vein; *F*, left auricle; *K*, inferior vena cava; *L*, division of right bronchus to lower lobe; *M*, right inferior pulmonary vein; *N*, right superior pulmonary vein; *O*, right branch of the pulmonary artery; *P*, division of right bronchus to upper lobe; *R*, left ventricle; *S*, right ventricle.

The right lung is the larger of the two, and has three parts, or **lobes**. The left lung has only two lobes. Each lobe is also made up of many groups of smaller parts, called **lobules**, each with its little bronchial tube, air sacs, and blood vessels.

The chest is lined and each lung covered with a smooth, delicate lining, called the **pleura**. These two surfaces rub against each other when we breathe. This lining secretes a fluid which keeps the parts moist and thus prevents an undue amount of friction.

225. How Nature protects the Air Passages. The inside walls of the windpipe and bronchial tubes are lined with a mucous membrane, which secretes a thick, sticky fluid called "mucus," to keep the passages moist. This membrane is covered with microscopic, threadlike processes called **cilia**, so close together that they resemble somewhat the pile on velvet. They seem to wave to and fro, like a field of grain under a gust of wind (Fig. 4).

The cilia always bend upwards and outwards towards the mouth with considerable force and then resume their former position with a very gentle movement. They sweep up bits of dust and mucus which are expelled by a sudden blast of air which we call coughing. These tiny cilia are simply the dusters which nature uses to keep the air passages neat and clean.

Experiment 48. The respiratory sounds may be heard fairly well by applying the ear flat to the chest, with only one garment interposed. Borrow a stethoscope from a physician and listen to the respiration over the chest. Note the difference of the sounds in inspiration and in expiration. Do not confuse the heart sounds with those of respiration.

Experiment 49. Place a large sponge, which will represent the lungs, in a paper bag which justs fits it; this will represent the pulmonary layer of the pleura. Place the sponge and paper bag inside a second paper bag, which will represent the parietal layer of the pleura. Join the mouths of the two bags. The two surfaces of the bags which are now in contact will represent the two surfaces of the pleura.

Experiment 50. Get a sheep's lungs, with the windpipe attached. Ask for the heart and lungs all in one mass. Examine the windpipe. Note the horseshoe-shaped rings of cartilage in front, which serve to keep it open. Put pieces of the lung tissue in a basin of water and note that they float.

Experiment 51. *To show how the lungs may be filled with air.* Take the lungs saved from Experiment 50. Tie a glass tube six inches long into the larynx. Attach a piece of rubber tubing to one end of the glass tube. Now inflate the lungs by blowing through the rubber tube several times and let them collapse.

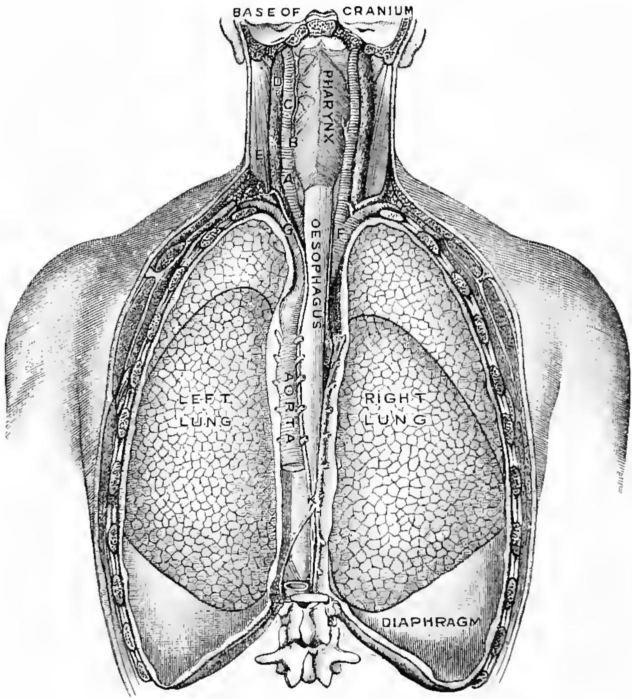

FIG. 103. Relative Position of the Lungs, the Heart, and Some of the Great Vessels belonging to the Latter. (Posterior view.)

A, left common carotid artery; *B*, external carotid artery; *C*, internal carotid artery; *D*, left jugular vein; *E*, sterno-cleido muscle; *F*, right innominate artery with branches to head and arm; *G*, left subclavian artery; *H*, great azygos vein; *K*, thoracic duct.

226. The Movements of Breathing. If we put both hands on the sides of our own chest and breathe in deeply, we feel that the act has carried the hands farther apart. Again, if we put one hand across the middle of our chest, we feel that it is carried forward every time we breathe in and is returned to its place as we breathe out.

Again, if we pass a tape measure round the chest and draw it tight when we breathe out, we find that the tape must be let out two or three inches as we breathe in. If we breathe in and out with a great deal of force, the changes are more marked.

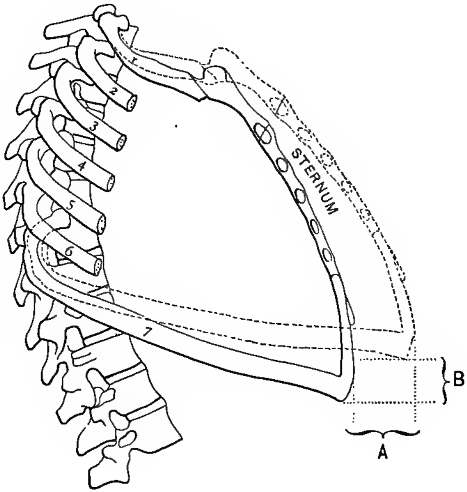

FIG. 104.

Diagram showing how, as the ribs move upward, the sternum moves forward, and increases the size of the chest during inspiration. The first seven ribs are numbered. Dotted lines indicate position in inspiration. *A* and *B* indicate the extent of the movement.

Hence there are two movements in breathing, in one of which the cavity of the chest is made larger in all its dimensions. This is when we breathe in air, and it is called **inspiration**.

The other movement is the one by which the chest cavity is made smaller. This is when we breathe out air, and it is called **expiration**.

The movements by which air is breathed in and out of the lungs make up the act of **respiration.**

227. How we breathe. The cavity of the chest is a closed, air-tight chamber, whose only opening is the windpipe. The pressure of the air in the air passages keeps the lungs stretched out so as to fill this cavity. Imagine now such a chamber as this to have a kind of floor, capable of moving up and down. When the floor moves down, the cavity will be enlarged, and the pressure of the air inside the lungs will then cause them to expand to a greater extent to fill up the extra space.

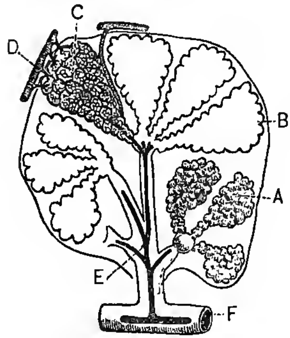

FIG. 105. BLACKBOARD SKETCH. A Lobule of the Lung.

A, an air sac; *B*, an air sac cut open; *C*, capillary network over an air sac; *D*, branch of pulmonary artery; *E*, branch of pulmonary vein; *F*, bronchial tube.

When the floor is raised again, the cavity will be diminished and the lungs, being diminished also, will give up the extra air which they have taken in.

The **diaphragm** serves as a kind of movable floor to the chest (Fig. 100).

These two movements are performed at regular intervals and constitute the process of **breathing.**

228. Inspiration and Expiration. The cavity of the chest, however, is enlarged in another way. The walls of the chest are formed by the ribs, which encircle it and join the breastbone in front. The spaces between the ribs are filled with a set of strong muscles called the **intercostal muscles.**

One set of these intercostal muscles contracts, and pulls up the ribs, which are fastened to the backbone behind by

a joint. When the ribs are raised, they push out the breastbone in front, and thus the cavity of the chest is enlarged. This enlargement by means of the side walls takes place at the same time that the diaphragm descends, so that the chest is enlarged in all its dimensions (Fig. 104).

An extra quantity of air then rushes into the lungs and we get an **inspiration.**

Immediately following the inspiration, the diaphragm relaxes, and, of course, rises; and, at the same time, another set of intercostal muscles begins to pull the ribs and breastbone down.

These combined movements diminish the cavity of the chest, and consequently the air is driven out. This makes an **expiration.**

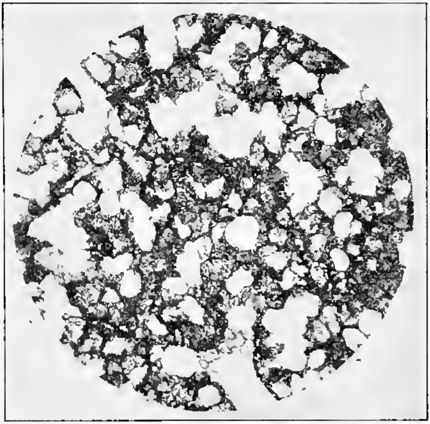

FIG. 106.

Showing the walls of air sacs with blood capillaries injected. The dark lines are the capillaries magnified about 30 times. The white spaces are air sacs cut across.

Experiment 52. *To show how the size of the chest varies during respiration.* Stand erect with shoulders well thrown back. While breathing naturally, allow some friend to pass a tape around the body just under the arms, bringing the ends of the tape together across the front of the chest. Take the exact measure (Fig. 104).

Repeat as before, while taking a long, deep inspiration. Hold the breath and measure as before. Note the difference in measurement.

229. The Air we breathe. The air that we breathe is chiefly a mixture of two gases, **oxygen** and **nitrogen**, in the proportion of one part of the former to four of the latter.

Oxygen is the active gas, the life-giving principle of nature. It has been well named "the great supporter of animal life."

Nitrogen is mixed with it, otherwise the oxygen would be too strong for us, and would burn us up too fast. In short, nature kindly tempers with nitrogen the air which we breathe.

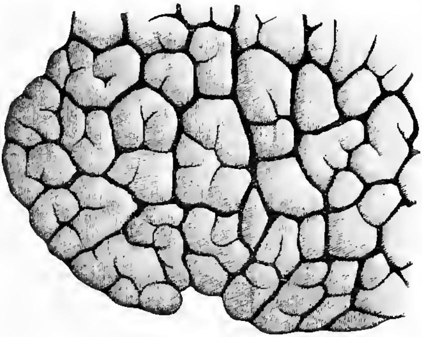

FIG. 107. A Portion of a Child's Lung.

Lobules of various sizes are well shown.

230. How the Air is changed in Breathing. If we examine the air before it enters the lungs, and again after it has passed through them, we shall find that, while the bulk is almost exactly the same, the composition has been changed. It has left behind about one quarter of its oxygen, and has taken in exchange for it nearly the same quantity of carbon dioxide, a gas which is destructive to life when present in large amounts. Carbon dioxide is not poisonous in itself, but its presence excludes the life-giving oxygen.

About thirty cubic inches of air pass in and out of the lungs with every breath, and more than three hundred cubic feet every twenty-four hours.

231. Other Changes in the Air we breathe. The air, as it leaves the lungs, is saturated with watery vapor. This is seen when we breathe on the bright steel blade of a pocket-knife, a mirror, or any cold, polished surface. As we all know, the surface becomes covered with a thin film, or minute drops of water. In cold weather this moisture becomes visible with each expiration.

Air as it leaves the lungs is warmer than the surrounding air. It is generally about 98° F. For this reason, on a cold day, when our breath passes off as a cloud of steam, we blow on our fingers to warm them.

The air breathed out of the lungs also contains a small amount of decaying animal matter. Everybody knows the unpleasant odor of the air in rooms in which many persons have been closely shut up.

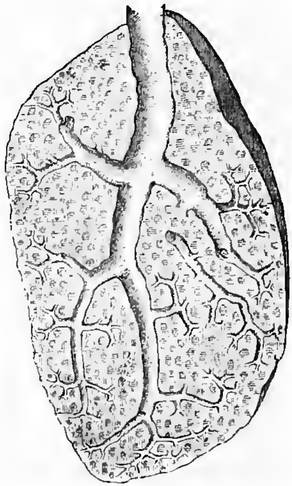

FIG. 108.

Showing the structure of a lobule of the lung. The lobule has been injected with mercury, afterwards dried and cut open. A large bronchial tube with its various branches is well shown.

Experiment 53. *To show that the air we expire is warm and moist.* Breathe on a thermometer for a few minutes. The mercury will rise rapidly.

Breathe on a mirror, a knife blade, or any polished metallic surface, and note the deposit of moisture.

Experiment 54. *To show that the expired air contains carbon dioxide.* Put a glass tube into a glass of clear limewater and blow through the tube. The liquid will soon become milky, because the carbon dioxide of the expired air unites with the lime held in solution and forms the white, solid carbonate of lime.

Experiment 55. Pass a tube through a cork; fix the cork tightly into a dry, wide-mouthed bottle. Breathe in and out of the bottle several times in succession until a feeling of suffocation is felt. The bottle will become moist and warm.

If, holding the bottle upside down, we take the cork out and pass a lighted splinter of wood within, the light will be at once put out, for the oxygen will have almost entirely disappeared, and it is replaced by carbon dioxide.

232. The Diffusion of Gases. Let us try to understand how this exchange of gases takes place between the air and the blood.

Experiments carried on outside of the body prove that gases can pass through delicate membranes. If a bladder is filled with oxygen and then hung in a bottle filled with carbon dioxide, the two gases will mix with each other. The oxygen will pass out through the thin membrane, and the carbon dioxide will pass in. This is in accordance with a well-known law of physical science and is known as the **diffusion of gases.**

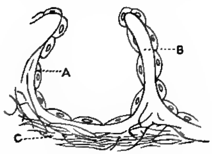

FIG. 109. Diagrammatic View of an Air Sac.

A, epithelial lining wall; *B*, partition between two adjacent sacs, in which run capillaries; *C*, fibers of elastic tissue.

233. Exchange of Gases between the Blood and the Air. An exchange of gases really takes place in the tissues of the body every moment of our lives. The blood and the air cavities of the lungs are separated from each other only by the thin and delicate epithelial lining wall of the air sacs and by the walls of the capillaries.

Blood with oxygen and carbon dioxide is on one side of this thin, moist membrane, and the air in the air sacs containing the same two gases is on the other side. The proportion of carbon dioxide in the blood is greater than

that in the air sacs, and the proportion of oxygen in the blood is less than that in the air sacs.

A **diffusion of the gases** takes place.

The blood, by this act of breathing, gains **oxygen** and loses **carbon dioxide**.

The air sacs lose **oxygen** and gain **carbon dioxide.**

234. Respiration in all of the Tissues. The blood thus freighted with oxygen travels to the left side of the heart, is pumped out through the aorta, and whirled away to the tissues in every part of the body. The tissues are most eager to combine with the life-giving oxygen and to give up carbon dioxide to the blood.

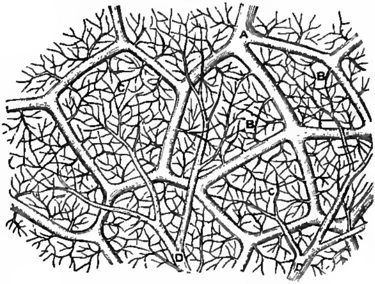

FIG. 110. BLACKBOARD SKETCH.

Diagram showing Capillary Network of the Air Sacs and Origin of the Pulmonary Veins.

A, small branch of pulmonary artery; *B*, twigs of pulmonary artery; *C*, capillary network around the walls of the air sacs; *D*, branches of network converging to form the veinlets of the pulmonary veins.

The oxygen given off to the tissues by the arterial blood in the capillaries may not be used to produce oxidation at once, but may be stored up for future use in muscular and other tissues.

During severe exercise the amount of carbon dioxide breathed out may often exceed the whole amount of oxygen taken in by the lungs during the time of action. In other words, during severe exercise the muscles may use up the oxygen which has been stored in their tissues during periods of rest.

235. Impurities in the Air. There are many things which may make the air we breathe unwholesome. The

poisoned air due to cesspools, drains, and sewers is a frequent source of disease. Sewer gas, the foul air from chemical works, bone and soap factories, and many other manufacturing places, may be hurtful to health.

Certain occupations may shorten life by exposure to air laden with impurities. Thus, there is the "miner's consumption," or "black lung," due to the dust which is breathed into the lungs, and acts like so many little splinters in the delicate air cells. Refiners of mercury work in a deadly atmosphere. Those who work on steel, emery, cutlery, pottery, etc., also suffer from the irritating dust floating in the air.

Other impurities are highly injurious to the lungs, as the dust in match factories, white-lead works, and copper and brass foundries. In fact, among some classes of factory workers the rate of mortality is higher than among firemen, freight brakemen, and men in other pursuits known to involve great risk of life.

236. How Bacteria may be carried in the Air. Many kinds of bacteria are carried in the air. Some of these germs may grow and produce disease if taken into the body through the air passages, in the food, or in drinking water. Thus, we shall learn that the germs of certain infectious diseases may be carried in the air and produce similar diseases in persons who may become infected by them.

The germs of disease after floating about in the air for a time may settle with the dust. If an infected room is not properly swept and dusted, there is an ever-present danger of spreading contagious diseases. Hence a sick room should be kept rigidly clean and furnished with a constant supply of pure, fresh air. It is well known that the dust in the streets of large towns contains the germs of disease.

237. The Dangers from Pulmonary Infection. There is an infectious disease called tuberculosis of the lungs, but commonly known as consumption. It is caused by the growth within the lungs of a disease germ called **bacillus tuberculosis.**

The sputum of a consumptive swarms with these bacteria. This infected matter, falling upon the street or about a room, soon dries and may become mixed with the common dust floating through the air. It may retain its vitality for a long time as a part of the dust of damp, filthy, or overcrowded houses. This dust when inhaled often finds in the body a congenial soil upon which the seeds of this dread disease may be transplanted.

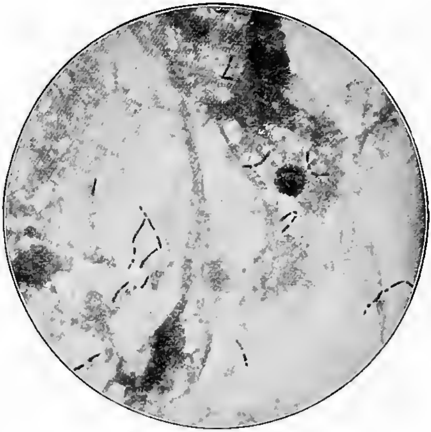

FIG. 111. Bacillus Tuberculosis.

A minute portion of sputum from a case of phthisis, or consumption of the lungs, magnified 1000 diameters. These bacilli are rod-shaped bacteria, stained to show black. The black spots in the figure are merely the débris in the sputum, also stained so that they look black.

238. Ventilation. The best way to rid our rooms and premises of impure air is by some suitable system of **ventilation,** — that is, some practical and efficient plan to keep the air pure and wholesome without making it too cold. If we do our best, however, we cannot keep the air of our living rooms as pure as the outside air; for, as we have seen, every person in the room, with every breath, is consuming the oxygen and imparting carbon dioxide to the air.

239. How to ventilate. An open fireplace is a safe, healthy, but not economical means of heating and ventilating a room. Stoves in a room soon dry the air, unless fresh air from outside is constantly supplied. When rooms are warmed by heated air from furnaces, the warm air should enter through registers near the ceiling, on one side of the room; and impure air should escape through outlets near the floor, on the other side.

Children should be trained from infancy to sleep with a window partly open for the greater part of the year. Adult people in vigorous health should gradually learn to do the same. Even in the coldest weather some plan of ventilation for the living rooms, but especially for the sleeping rooms, should be provided. Draughts must be avoided.

Any simple apparatus to let in fresh air will answer every purpose. Raise the window a few inches and put a piece of board under the lower sash. Pure air will enter where the two sashes overlap.[1]

[1] Above all things, avoid sitting, standing, or lying in a cool, breezy place when you are warm from active exercise. This is a sure way to catch cold. Do not stand by open windows or open doors when the air of the house is warmer than that outside. You are subjected to a strong draught, which is sure to result in a cold. Do not stop to talk in the doorway when parting from a friend.

Do not throw off your wraps too suddenly when coming in warm with exercise.

Do not talk much when walking in the cold, frosty air, but keep the mouth closed, that the air may be warmed by the nostrils.

Avoid very hot rooms with the moisture all dried out of the air. Change the air of your room every hour. An hour is long enough to remain in one position or in one room without change.

Never sit, eat, or sleep in a north room if you can help it. The north side of the house belongs to the refrigerator and the storeroom. Let the sun shine into all your rooms as much as possible. You had better have faded carpets than faded faces. — DR. MARY J. STUDLEY, in *What Our Girls Ought to Know.*

240. Ventilation of Schoolrooms. Special pains must be taken to ventilate schoolrooms. Pupils are sure to become listless, uneasy, dull, and sleepy when the air is not wholesome. Children may be comfortable in a well-aired room at 66° F., but it is very easy to let the temperature run up to 80°, or even above, before it is noticed.

Whatever apparatus for ventilation may be used, the doors and windows should be opened before and after each session and at recess.

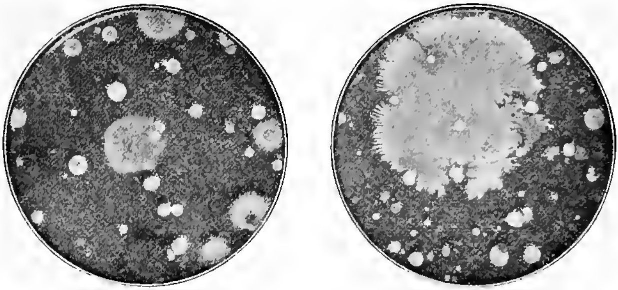

FIG. 112.

Two petri dishes: one, *A*, exposed to the air before, and the other, *B*, exposed after, a class had occupied a recitation room. Plate *A* shows few bacteria, while plate *B* contains large numbers.

The air of the schoolroom should be changed as often as once every hour. The pupils meanwhile should engage in active gymnastic exercises to prevent taking cold. When this is done in cold weather, the heat should be turned on and the fresh, cold air warmed as quickly as possible.[1]

[1] School children sitting at their desks, clerks bending over their ledgers, seamstresses at work with the needle or the sewing machine, stenographers, typewriters, and all who must stoop as they earn their daily bread, should learn to stop from time to time, sit back in the chair or rise, throw back

241. The Natural Heat of the Body. Everybody knows that the surface of the body feels warm. Hold the fingers in the mouth and we find it warm. Put a thermometer, made for the purpose, in the mouth and under the tongue for five minutes, and it will register about 98° F., even on

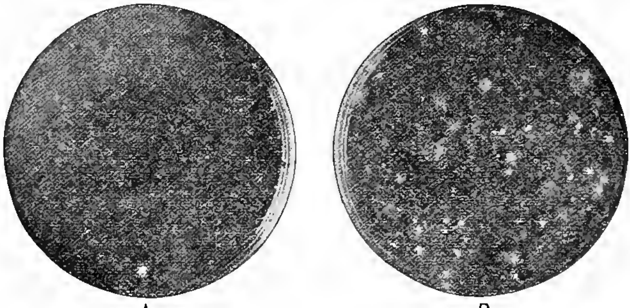

FIG. 113. Photographs of Two Plates filled with Jelly upon which Molds will readily grow; showing Abundance of Mold Spores in the Air.

Plate *A* was opened to the air for one minute in an ordinary room, and then closed. The room was then swept and plate *B* exposed to the air for the same length of time. Both plates were then set aside until the spores germinated, when the photographs were made. Plate *A* shows only one mold, while plate *B* contains large numbers. Dusting a room produces similar results.

the coldest day of midwinter. This is the natural heat of a healthy person, and it rarely varies more than a degree or two, except in disease.

the shoulders, and draw in ten or twelve deep, slow inspirations, holding the breath for three or four seconds each time the lungs are filled.

These exercises, like breathing in general, should always be done with the mouth closed, for the nose is the only proper channel for the passage to and fro of the air. A school teacher who will interrupt the studies once every hour through the session, and teach the class to do this breathing exercise, will be contributing more than she can ever realize to the future well-being of her pupils.

242. How the Bodily Heat is produced. The heat of the body is produced in just as simple a manner as that which comes from a common fire or a lighted candle. It is the natural result of the process of combustion. Our bodies are warm because we are burning away bit by bit, just as a candle does, — that is to say, by the union of carbon, or charcoal, with oxygen. There is only this difference: we burn wet materials (the moist tissues), and do not give out flame or light. In place of coal or tallow we take in fuel in the shape of starch, sugar, and fat and get the oxygen from the air we breathe.

A steam engine at work is warm because all the energy set free from the fuel burned is not turned into mechanical work, but some of it appears as heat. So it is in our bodies. Every tiny cell of every bit of tissue is busily at work, and its substance is slowly being burned at a low temperature. Every time we move, feel, or think, this oxidation, or burning, goes on in all the tissues of the body.

Some of the energy thus set free by this slow combustion shows itself as heat, which helps to keep the body warm and at its natural temperature. Thus, animal heat is produced and life maintained.

Experiment 56. *To show the natural temperature of the body.* Borrow a physician's clinical thermometer and take your own temperature, and that of several friends, by placing the instrument under the tongue and holding it there for five minutes, keeping the mouth closed. Read it while in position, or the instant the instrument is removed. The natural temperature is about 98½° F. The thermometer should be thoroughly cleansed after each use.

243. How the Body loses its Heat. Our bodies are warmer than the surrounding air, except in the hottest weather; hence there must be a loss of heat nearly all

the time. Therefore we must keep making heat to make up for this continual loss, known as "radiation."

Besides this loss by radiation considerable heat is given off in the moisture which is got rid of by the skin in forming vapor, or sweat. The evaporation of this moisture from the skin acts as a kind of regulator to keep down the excess of heat.

244. Effect of Alcohol upon the Lungs. We have learned in previous sections that the most marked and immediate effect of even a moderate amount of alcohol is upon the nerves. This effect is evident, as we have read, in the paralyzing action of alcohol upon the nerves which control the muscular walls of the arteries. These muscles are relaxed, and the blood vessels are dilated and filled with an unusual amount of blood (Sec. 215).

This action of alcohol also shows itself in dilating the minute blood vessels, or capillaries, of the lungs. This distension of the capillaries, if long continued, tends to reduce the size of the air sacs and affords less space for the air which is needed by the pulmonary tissues. The result is that less oxygen is supplied to the blood.

245. Relation of Alcohol to the Breathing Capacity of the Lungs. When the capillaries of the lungs have been distended for a long time by the long-continued use of alcoholic liquors, the walls may become thickened and hardened. The result is that the breathing capacity of the lungs is diminished. This loss in breathing space tends to prevent the interchange of gases whereby the life-giving oxygen is taken into the blood and carbon dioxide is cast out of the body.

The apparatus called the "spirometer," used by medical examiners of life-insurance companies to test the breathing

capacity of the lungs, often detects the dram drinker by his failure to reach the natural breathing capacity.

The repeated dilatation of the lung capillaries also tends to make the habitual user of alcohol less able to resist attacks of severe cold, pleurisy, and pneumonia, after making due allowance for the exposure to cold and damp, so common with the intemperate.[1]

246. Alcoholics and Pulmonary Consumption. A notion has prevailed that the use of alcoholic liquors may act as a preventive of pulmonary consumption. The records of medical science fail to show any proof whatever to support this idea. No error could be more serious or more misleading. Alcohol, if it does not predispose to pulmonary consumption, as many believe, certainly furnishes no protection against it.

247. Alcohol and Bodily Heat. Soon after taking even a small quantity of alcohol there is a general feeling of warmth over the surface of the body. The body is not really warmer, but the skin feels warmer. On the contrary, we are really colder, because heat is more rapidly lost by radiation and evaporation from the surface.

[1] Most familiar and most dangerous is the drinking man's inability to resist lung diseases. — ADOLPH FRICK, M.D.

There is good reason to believe that the use of spirituous liquors among the working classes of the country is productive of consumption and tuberculous diseases to an extent far beyond what is usually imagined. The blanched, cadaverous aspect of the spirit drinker bespeaks the condition of his internal organs. The tale of his moral and physical degradation is indelibly written on his countenance. The evil, however, does not rest here; for by destroying his own health he entails on his unhappy offspring the predisposition to tuberculous diseases. — SIR JAMES CLARK, M.D.

Alcohol is a frequent cause of consumption by its power of weakening the lungs. Every year we see patients who attend the hospital for alcoholism come back after a period to be treated for consumption. — DR. LEGENDRE, a famous Paris physician.

The skin is warmer after taking alcoholic liquor, because the nerves that regulate the threadlike blood vessels on the surface, being partly paralyzed or deadened, dilate and allow more blood to flow through them. Hence more blood is sent from the central parts of the body to the surface. There is no real increase of heat: the surface is warmed for the time at the expense of the inner and deeper portions of the body.

This surface warmth is rapidly lost by radiation, and the general heat of the body is lowered below its natural temperature. The bodily temperature is partly regulated by the surface circulation; and when this control is lost, as it is by alcohol, the body is cooled by the undue amount of blood carried to the surface.

The notion that a dose of some alcoholic liquor taken after exposure or bathing will prevent one from taking cold is erroneous. The alcohol, by irritating the delicate lung tissues and lining of the air passages, and reducing the temperature of the body, makes one more liable to colds, coughs, pneumonia, etc. When we feel chilly, the best thing to do is to get thoroughly warmed as quickly as possible, either by active exercise or by artificial heat.

248. Alcohol and the Endurance of Extremes of Heat or Cold. Experience has proved, time and time again, that alcohol lessens the power to endure the extremes of heat or cold for any length of time. Arctic explorers strictly forbid the use of alcoholic liquor among their men because they know that exposure to severe cold can be endured far better without it. So well is this effect of alcohol known by the people of the coldest regions of Canada, that they will seldom take even a single glass of spirits when exposed to severe cold.

Army life is perhaps the best possible test. It is the almost universal experience of British army officers who have led their men through arduous campaigns in the hottest parts of Africa, and who have given much study to the question, that alcohol, so far from being an aid to endure severe exertion and to resist great extremes of heat, acts as a positive injury.[1]

General Kitchener prohibited all drinks containing alcohol in the Sudan campaign. Respecting the result, a war correspondent said: "Of one thing I am sure, — that the mortality from fever and other diseases during the Atbara campaign and the final Omdurman campaign would have been infinitely greater than it was if alcoholic liquors had been allowed as a beverage, or even as an occasional ration."

Lord Roberts, the British commander in the Boer war, claims that the effective power of an army to endure extreme heat and cold is always in proportion to the number of total abstainers in the ranks.

[1] A party of engineers were surveying in the Sierra Nevadas. They camped at a great height above the sea level, where the air was very cold, and they were chilled and uncomfortable. Some of them drank a little whisky and felt less uncomfortable; some of them drank a lot of whisky and went to bed feeling very jolly and comfortable indeed. But in the morning the men who had not taken any whisky got up in good condition; those who had taken a little whisky got up feeling very miserable; the men who had taken a lot of whisky did not get up at all: they were simply frozen to death. They had warmed the surface of their bodies at the expense of their internal organs. — T. LEANDER BRUNTON, M.D. (St. Bartholomew Hospital, London), in *Lectures on the Action of Medicine.*

QUESTIONS ON THE TEXT

1. What may be said in a general way of the act of breathing? 2. What have we learned in previous chapters about food and the blood? 3. What have we learned previously about the circulation of blood in the lungs? 4. State in a general way the twofold object of breathing. 5. Through what passages is air drawn into the lungs? 6. What are the nostrils? 7. Describe the windpipe. 8. What is the epiglottis? 9. Describe the larynx. 10. Into what two branches is the windpipe divided after entering the chest cavity?

11. Describe the bronchial tubes. 12. What are the lungs? 13. What is meant by the lobes and the lobules of the lungs? 14. What is the pleura? 15. How may the respiratory sounds be plainly heard? 16. What useful purpose do the cilia serve?

17. How may we note the general movements of breathing in our own persons? 18. Give brief definitions of inspiration, expiration, and respiration. 19. Explain in some detail the mechanical movements in the act of breathing. 20. What part do the intercostal muscles play in the process of breathing?

21. Of what is the air we breathe composed? 22. How is the air changed in breathing? 23. Mention some other changes in the air that take place during breathing. 24. What is meant by the diffusion of gases? 25. What exchange of gases takes place between the blood and the air in breathing? 26. What does the blood gain and lose in the process of breathing? 27. What do the air sacs gain and lose in breathing? 28. Describe the process of respiration in all of the tissues. 29. Mention some things that may make the air impure. 30. How may the germs of disease be carried in the air?

31. Explain how the sputa of persons suffering from pulmonary consumption may become a source of contagion. 32. Give some practical hints about ventilation. 33. Why and how should schoolrooms be ventilated? 34. How can we ascertain the temperature of the body? 35. Explain in a general way how the bodily heat is produced. 36. How does the body lose its heat? 37. What is the general effect of alcohol upon the lungs? 38. What effect does alcohol have upon the breathing capacity of the lungs? 39. How does alcohol modify the bodily heat? 40. Explain how alcohol lessens the power to endure the extremes of heat and cold.

CHAPTER IX

THE SKIN AND THE KIDNEYS

249. How our Bodies are covered. The **skin** is the outside covering of the body. We all know how painful and tender any part of the body is when this covering has been torn, cut, blistered, burned, or otherwise hurt.

Kind nature has given us a firm, elastic, and tight-fitting outside garment. It is easily kept clean, and never wears out. It is soft and thin enough to enable us to feel objects easily, yet thick and strong enough to allow us to do this without pain.

250. The Skin and its Two Layers. The skin consists of two layers. The outer one has neither blood vessels nor nerves, and is called the **cuticle, scarfskin,** or **epidermis.**

The deeper layer, called the **true skin,** or **dermis,** is so highly sensitive that, were it not for the outer layer, we could not endure life. Most of us are familiar with the delicate pink skin which is exposed when the outer skin is removed by a blister, or rubbed off by some slight accident. The surface feels raw, and from it oozes a little clear fluid called "lymph," or perhaps a little blood. Beneath the true skin there is a layer of fat which gives roundness and softness to the figure.

251. The Scarfskin. The deeper portion of the **scarfskin** is constantly producing millions of little cells to take the place of the flat, horny, and lifeless scales of the outer

portion, which are continually dropping off or being removed by friction.

When these flattened scales are pressed together, they become flatter and flatter; and thus the hard, horny skin is made, which is seen in places where the wear and tear is considerable, as in the palms of the hands and the soles of the feet. The callous places on the hands of the blacksmith, the carpenter, or the washerwoman are familiar.

252. What gives the Skin its Color. In the deeper parts of the scarfskin are tiny specks of coloring matter, hid in little cells. These give the skin its color. In the fairer races, these specks are of a pinkish color; in the dark races, the pigment cells are brown or nearly black, and more closely crowded together.

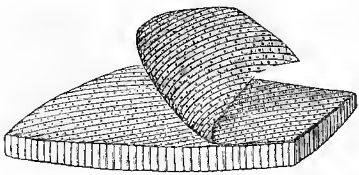

FIG. 114. A Layer of the Outer Skin from the Palm of the Hand.
Detached by maceration.

The rays of the sun serve to darken these color specks, as is seen in the parts of the body exposed to direct sunlight. We often see on the persons of laboring and athletic people a sharp line drawn between parts of the arm or neck exposed to the sun's rays, and other parts generally covered with clothing. Some persons, however, tan much more readily than others. When the pigment changes in spots, we call them freckles.

Experiment 57. Take a very fine and perfectly clean needle and run the point carefully beneath the thin outer layer of the skin at the junction of the fingers with the palm of the hand. Note that the point of the needle is not felt and that there is no flow of blood.

253. The True Skin. The **true skin**, or **dermis**, is a firm, elastic structure resting on meshes of a tissue something like damp, raw cotton, which loosely fasten the skin to the parts beneath. It is the true skin which, in the lower animals, is made into leather by the process of tanning. In this layer also are the nerves, blood vessels, and absorbents of the skin.

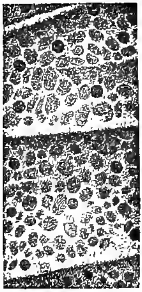

FIG. 115. Epidermis from the Bottom of the Foot.

When the true skin is destroyed, a scar results. White scars, especially on the hands, due to deep cuts, and scars from smallpox, deep burns, and other injuries to this layer of the skin, are often seen.

The true skin is richly supplied with nerves and blood vessels so closely netted together that it is next to impossible to prick the skin anywhere with the point of a needle without drawing blood and feeling pain.

Experiment 58. Stretch the thumb and forefinger of the left hand wide apart. Gently prick the skin with the point of a fine, clean needle. Note how sensitive the true skin is, and how readily a drop of blood may flow.

Experiment 59. Press the thumb of the right hand tightly into the left palm. Remove the thumb quickly. Note the difference in color of the spot pressed and that of the skin near by.

254. The Skin and the Sense of Touch. The outer surface of the true skin rises up into the epidermis so as to form little hillocks, or **papillae**, into which run the capillaries and the nerves.

In the papillæ are little round or oval bodies, called **touch corpuscles** (Sec. 340).

These papillæ are very numerous everywhere, but are thickest where the sense of touch is most acute, as on

the tips of the fingers. They are arranged in rows, like hills of corn, and sometimes in whorl-like patterns, which are plainly seen with a magnifying glass on the palms of the hands or the balls of the fingers.

Experiment 60. Dip the end of a wooden toothpick into some thick ink and spread it very thin over the end of the forefinger, or press the end of the finger on a color pad. Now press the finger tip on a piece of heavy, uncoated paper. Study the impression made by the ridges on the finger.

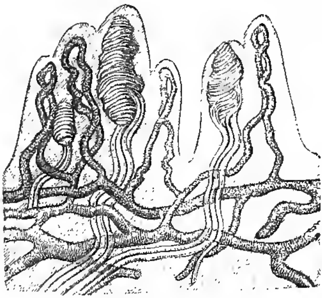

FIG. 116. Papillæ of the Skin in the Palm of the Hand.

In each papilla are seen vascular loops (dark lines) running up from the vascular network below; the tactile corpuscles (white lines) which supply the papillæ are also shown.

Experiment 61. The living skin can be examined only in a general way. Stretch and pull it, and notice that it is elastic. Examine the outer skin carefully with a strong magnifying glass. Study the papillæ on the palms. Scrape off with a blunt knife a few bits of the scarfskin, and examine them with a magnifying glass.

255. How the Skin may absorb Poison. The outer skin helps to protect the true skin from poisons. Lead, mercury, and other injurious substances will not enter the blood and affect the health, unless they are actually rubbed through the dermis; but if there is a scratch or sore, so that the true skin is exposed, the poisons may be absorbed into the blood with great rapidity.

Workers in lead, looking-glass silverers, and phosphorus match makers ought, therefore, to take great care to cover the smallest scratches on their hands. "Lead colic" and "wrist drop" are familiar instances of lead poisoning.

FIG. 117. The First Vaccination.

This picture is based upon a photograph of a painting exhibited many years ago in the Paris Salon. It represents the crowning experiment of Dr. Edward Jenner, a famous English physician and the discoverer of vaccination. The experiment was performed on a boy whom Jenner inoculated with matter taken from the hand of a milkmaid who had been directly infected by the cow. This was on the 14th of May, 1796, — more than a century ago.

The picture is used by the kind permission of William Wood & Co., publishers.

Cheap underclothes, as colored stockings, are often dyed with preparations of lead. Such articles should be thoroughly washed before they are worn. Many hair dyes contain lead, and may cause lead poisoning.

256. Absorption of Infectious Matter by the Skin. The fact that certain infectious matters are easily and rapidly absorbed by the skin has long been utilized by people who have learned to safeguard themselves against the ravages of smallpox. A bit of the outer skin is scraped away with a pocketknife or some other convenient instrument. On the moist, denuded skin is placed the vaccine matter from a quill, or even matter obtained from a smallpox pustule.

Many years ago, when smallpox was very common and fatal in England, the attention of a young medical student, named Jenner, was forcibly attracted to the nature of the dread disease in the following manner. One day a young milkmaid came to seek his advice. Speaking of smallpox, the girl said, "I cannot take that disease, for I have had cowpox." Jenner began a long series of experiments and observations to explain this remarkable fact. The actual discovery of vaccination was delayed for many years (Fig. 117 and Sec. 427).

257. Structure of the Hair. A hair is made up of horny cells of the outer layer of the skin altered in shape and structure. It grows from little sacs in the true skin called **hair follicles.**

Every hair has two parts, — the root and the free end. The root is somewhat pear-shaped and is sunk in its sac, or follicle, like a post into the ground. In the bottom of this sac is a little **hair papilla**, quite different from the papillæ of the skin. From this comes material for the growth of the hair. As long as this papilla is not destroyed, the hair will grow. If we pull out the hair from the roots, it will

grow again. If we destroy this papilla, the hair never grows again.[1]

The hair follicles are well supplied with nerves, hence it hurts to have the hair pulled.

258. How the Hairs grow. Hairs grow from cells pressed together lengthwise, so that they are drawn out into fibers instead of being flattened into scales. Hence they grow only in length. On the outer surface the cells form a sort of bark, overlapping each other something like the shingles on a roof.

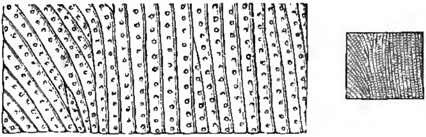

FIG. 118. BLACKBOARD SKETCH.

Surface of Palm of the Hand, showing Openings of Sweat Glands and Grooves between Papillæ of the Skin.

Magnified 4 diameters.

In the smaller figure the same epidermal surface is shown as seen with the naked eye.

The coloring matter is contained in the cells. It is this pigment which gives the great variety in color. The hair usually becomes gray or white as old age comes on. The pigment is absent and the cells are filled with air bubbles.

259. Muscles that control the Hairs. The hairs, or rather the parts of the skin close to them, are provided with tiny muscles. They run from the bottom of each hair follicle in a slanting direction, and end in the outer part of the true skin. When they contract they cause the

[1] It is useless, or worse than useless, to try to rid one's self of unsightly hairs or hair moles on the face. If we pull them out with tweezers, or cut or shave them off, they are sure to grow again, coarser and more unsightly than before. Remedies advertised to remove superfluous hairs are usually worthless or dangerous. The hair papillæ must be destroyed to stop the growth of hair, and this is no simple matter.

hair to stand more or less erect, and the skin to bunch up a little. Thus, at the sight of a dog, the hairs on a cat's back become erect and bristling.

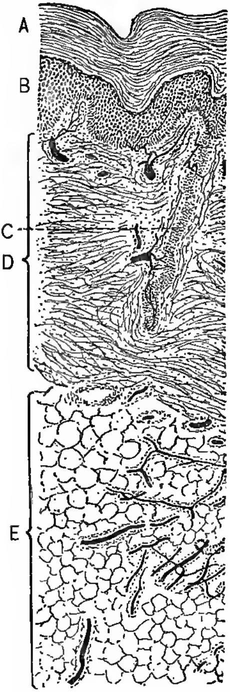

FIG. 119.
BLACKBOARD SKETCH.
Cross-Section of Skin.
Magnified 30 diameters.
A, outer layer of cuticle; *B*, deeper layer of cuticle; *C*, duct of sweat gland; *D*, true skin; *E*, sublayer of true skin, with columnar cells. The blood vessels are injected to show black.

Any one who has been frightened suddenly, or has taken a chilly bath, knows what it is to have "goose flesh." These muscles also act to force oil out of the oil glands (Fig. 125).

The hair serves to protect the parts it covers from heat and cold. On the head, the hair helps to protect the skull from injuries and the brain from extremes of heat and cold.

260. The Nails. The **nails** are horny cells of the epidermis in a hardened and thickened form. They grow from roots which are lodged in a groove of the skin, somewhat as a watch crystal is fitted into its case. The part which is beneath the skin is called the **root,** and the remaining part the **body.** (Figs. 122–124).

The nail rests upon a bed, called the **nail bed** or **matrix,** to which it is firmly fastened. Nails grow from the root, and as long as this is not injured they are not lost or disfigured by splinters, blows, and bruises.

Disease or injury of the root generally results in a badly shaped nail. The nails serve by their horny texture to protect the outer portions of

the ends of the fingers and toes from injury, and to give a support for the fleshy ends.

261. The Care of the Finger Nails. The finger nails grow out about three times a year. They should be trimmed once a week, leaving them long enough to protect the ends of the fingers. Nails should never be trimmed to the quick. They should not be cleaned with anything harder than a brush or a bit of soft wood. They should not be scraped with a penknife or anything metallic, as it destroys the delicacy of their structure, and gives them an unnatural thickness.

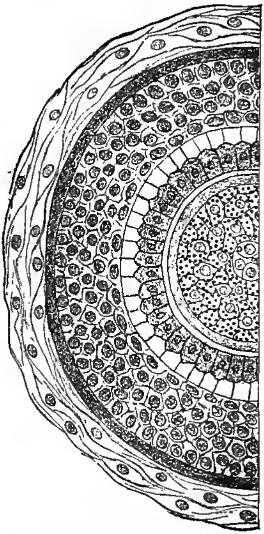

FIG. 120. Cross-Section of One Half of a Human Hair.

Magnified about 300 diameters.

"Hangnails" are caused by the skin fastening itself to the nail, which, growing outward, drags the skin along with it, stretching it until one end gives way. To prevent this, the skin should be loosened from the nail once a week, not with a knife or scissors, but with something blunt, such as an "orange stick," made for this purpose, the small end of a nailbrush, or an ivory paper cutter.[1]

[1] An ingrowing toe nail often causes much pain and inconvenience. It is found most commonly on the side of the great toe, although it may occur on any one of the smaller toes. Ill-fitting boots and shoes in which the toes are cramped together usually cause the trouble.

The toe nails should always be cut off square, at a right angle to the axis of the toe, and should never be pared close and rounded off at the sides parallel with the extremity of the toe. If they are rounded there is

262. The Oil Glands. The **oil glands** are little round sacs clustered together like a bunch of grapes, with a tube which opens into the hair follicles.

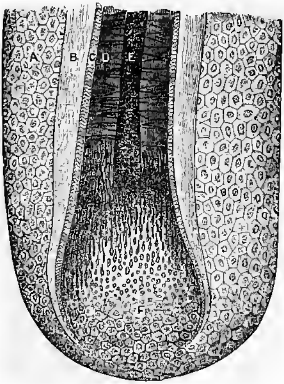

FIG. 121. Section of Lower Portion of a Hair and Hair Follicle.

Highly magnified.

A, membrane of hair follicle, showing cells with nuclei and pigmentary granules; *B*, external lining of root sheath; *C*, internal lining of root sheath; *D*, cortical or fibrous portion of hair shaft; *E*, medullary portion (pith) of shaft; *F*, hair bulb, showing its development from cells.

Generally there are two to each hair, but in some places there are from four to eight around a hair, making a kind of collar about it. These glands furnish a natural dressing for the hair and keep it moist and glossy. They also keep the surface of the skin soft and flexible.

In some places the oil glands, as upon the nose, chin, and forehead, are large, and the hairs very small; hence it often occurs that they open directly upon the skin. In these openings the oil is likely to collect and become hard.

Bits of dust get into these glands, acting like plugs, and show themselves as small black specks, incorrectly called "flesh worms," because of the resemblance which these little masses

nothing left to support the side of the toe, and the pressure of the shoe then causes the fleshy parts to ride up over the side of the nail, and as the latter grows it has to cut its way into soft parts, for it has nowhere else to go.

The wound so caused cannot heal, for the sharp side of the nail is always cutting farther into it and producing irritation. Soon it becomes inflamed; then matter forms, "proud flesh" grows up over the side, and a most painful and crippling condition may result. Home treatment often makes bad matters worse. A chiropodist's services are often needed.

have to a worm. This oily secretion, which might well be called nature's hair oil, is perfectly fluid in a healthy skin, and at the temperature of the body.

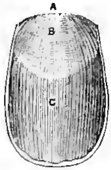

FIG. 122. Concave or Adherent Surface of Nail.

A, border of the root; *B*, whitish portion of semilunar shape; *C*, body of nail. The continuous line around border represents the free edge.

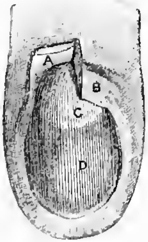

FIG. 123. Nail in Position.

A, section of cutaneous fold turned back to show root of nail; *B*, cutaneous fold covering root of nail; *C*, semilunar whitish portion; *D*, body of nail.

263. The Sweat Glands. The **sweat glands** consist of very fine tubes, about one quarter of an inch long, coiled into knots. From each knot a canal, called a **sweat duct,** rises up through the dermis and, piercing the epidermis in corkscrew fashion, opens on the surface of the skin.

The openings, or small pits, of these sweat glands are set in rows, as may be seen by a common magnifying glass, especially on the palms of the hands between the ridges of the skin. On the sole of the foot and the palm of the hand they are very numerous, there being some three thousand of them to the square inch; while on the cheeks there are only about five hundred and fifty in the same space, and about twelve hundred to the square inch on the forehead. At a rough estimate, there are more

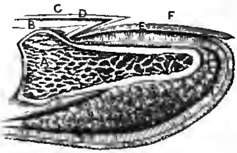

FIG. 124. Longitudinal Section of a Finger Nail.

A, last bone of finger; *B*, true skin on the dorsal surface of finger; *C*, outer skin; *D*, true skin; *E*, bed of nail; *F*, superficial layer of nail; *H*, true skin of pulp of finger.

than two million sweat glands in the whole body. If they were laid end to end, they would stretch to a distance of nearly ten miles.

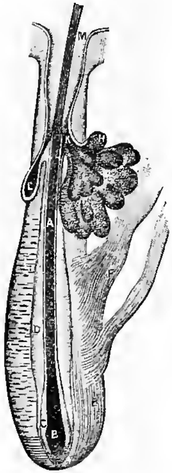

FIG. 125. BLACKBOARD SKETCH.

Hair and Hair Follicle.

A, root of hair; *B*, bulb of hair; *C*, internal root shield; *D*, external root shield; *E*, external membrane of follicle; *F*, muscular fibers attached to follicle; *H*, compound oil gland with its duct, *K*; *L*, simple oil gland; *M*, opening of hair follicle.

Experiment 62. Study the openings of the sweat glands with the aid of a strong magnifying glass. They are conveniently examined on the palms.

264. The Sweat, or Perspiration. The **sweat,** or **perspiration,** is a colorless, salty fluid, with a peculiar odor. It is a part of the waste matter of the tissues which has been filtered from the blood and is got rid of through these busy little glands in the skin.

These glands are always at work pouring out sweat. This may not be evident to the eye or to the touch, because it evaporates into the air as fast as it is formed. In hot weather, or during exercise, the sweat is poured out faster than it can evaporate. It often collects in drops and runs down our faces.

The average daily quantity of perspiration is not far from two pints, but this, of course, is much increased in hot weather. It varies greatly, according to what we are doing, the condition of health, how we are clothed, and the temperature of the surrounding atmosphere.[1]

[1] Horses sweat all over the body, and so do human beings, but monkeys, it is said, sweat only on the hands, feet, and face. In animals that perspire

Experiment 63. Press the palm of the hand gently on a hand glass or mirror. If convenient, have the surface of the glass cold. Repeat the process with the back of the hand. Note any difference in the relative amounts of perspiration. Try these experiments on a very hot and a very cold day, and note the difference in the activity of the skin.

265. Why we sweat. The most important function of the sweat is to regulate the temperature of the body by evaporation from its surface. We fan ourselves on a hot day to hasten this evaporation of the moisture on the skin. In hot weather, and after taking a hot drink or a hot-air bath, the skin does its best to reduce the temperature, and thus works all the harder in pouring out the sweat more profusely. When one is perspiring freely, it is highly imprudent to sit in a cool draught; for this evaporation may be suddenly checked, and we are then apt to take cold.[1]

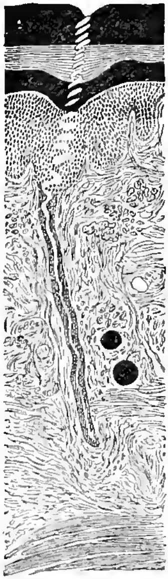

FIG. 126. BLACKBOARD SKETCH.

Vertical Section of the Human Skin.

Magnified 30 diameters.

Showing three outer layers of the cuticle, — two in black and a middle light layer. Below the inner dark layer, the active layer (*rete mucosum*) is well shown. All below is the true skin. The tortuous course of a sweat gland is well marked. The two round black spots are fat cells.

[1] Some people are afflicted with a naturally strong and disagreeable odor of the ... but little, the cooling of the body is effected chiefly by evaporation from the tongue, as we see in the case of a panting dog.

Profuse sweating is very common in cases of debility and in excessively stout persons. It occurs also in connection with various diseases. Sudden emotion may cause increased perspiration.

¹ Some people are afflicted with a naturally strong and disagreeable odor of the

266. Why we should take care of the Skin. Many thousands of sweat glands in the skin, acting like drainage tubes, together with the countless oil glands, pour out daily about two pounds of sweat, oil, and other used-up matters through the hard-worked skin.

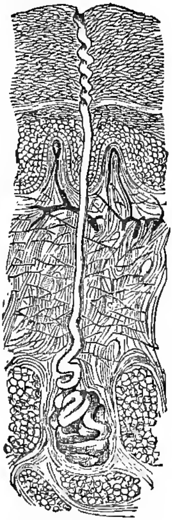

FIG. 127.

BLACKBOARD SKETCH.

Vertical Section of Skin showing Sweat Gland with its Duct.

The convoluted gland is seen surrounded with fat cells and may be traced through the true skin to its outlet in the horny layers of the outer skin.

The perspiration evaporates and leaves the solid and oily matters to plug the mouths of these tiny sewer pipes.

The dead scales of the scarfskin are continually dropping off. They become sticky with the oil, and, getting entangled in the meshes of the clothing, become glued in a kind of thin crust to the surface of the body. This, if not regularly washed off, attracts dirt and dust.

The glands of the skin thus get choked up and are not able to do their work properly. Other organs, such as the lungs and the kidneys, now have to do their own work and help do that of the skin besides. The balance of health is disturbed

perspiration. In some cases this is caused by ill health, but in many, perhaps most, cases, it is natural to the sufferer, and can only be overcome in a measure by extreme care of the person and attention to the bath. Sponging the body with water containing a few drops of ammonia may afford some relief.

Frequent change of clothing will be necessary, and dress shields should be worn by all who have this unpleasant infirmity, and the same suit or dress should never be worn on two consecutive days.

because the blood is not properly purified, and disorders of various kinds are almost sure to result.

267. Baths and how to take them. The first object in using soap and water on the skin is to keep it clean; the second, to give vigor and strength to the whole body.

It takes very little time, expense, or trouble to take a daily bath of some sort. A hand basin, a sponge, a strip of cotton flannel, a piece of Castile soap, a gallon of water, and a towel are all that are required. Even rubbing the body every day, first with a damp towel and afterwards very briskly with a dry one, will, in most cases, keep the skin clean enough during the week, provided a bath with warm water and soap is taken at the end of the week.

Coarse and rough towels should always be used if the skin will bear it. Some skins are very active and get rid of a large amount of waste matter. In such cases, a daily bath, especially in hot weather, is almost a necessity.

Hot baths, with hot drinks, causing free sweating, helped on by wrapping the person snug in bed, with a jug of hot water or a hot flatiron at the side or feet, will often save children and others from illness, if these measures are promptly and vigorously taken after unusual exposure to cold or wet.

268. Bathing in Cold Water. Most persons, especially the young and vigorous, soon get used to cool, and even cold, baths. If, however, we shiver after a bath instead of feeling a warm, comfortable glow, warmer water should be used.

The first effect of any cold bath is to cause contraction of the vessels of the skin, and make the surface pallid. Brisk rubbing should soon bring on a reaction, as it is called, in which the skin becomes red and full of blood. Always

stop bathing if shivering comes on, and use the towel vigorously until a feeling of genial warmth is felt all over the person.

Young children and old people, unless strong, vigorous, and well used to it, cannot take a cold bath without some risk. Like all other things, bathing may be weakening if carried to excess. Very much depends upon a person's occupation and the condition of the skin.[1]

269. The Care of the Hair. It adds to our health and comfort to keep the hair clean. The oil glands become clogged, and dust and dirt, rapidly making a coating on the scalp, get entangled in the hair. Hence the hair should be washed, combed, and brushed, often and well. An occasional shampoo at home, with a wash made of the white of an egg and soapsuds, is healthful. Even a little borax dissolved in plain water, with vigorous rubbing, will do much to keep the scalp clean and healthy.

270. Dangers from Change of Clothing. Clothes serve to keep up an even temperature about the surface of the

[1] Certain precautions are advisable for all who bathe in the sea. In the first place, bathing should never be indulged in when one is overheated, nor within two hours after a hearty meal. On the other hand, bathing on a perfectly empty stomach, as before breakfast, is not advisable; it is a good plan for early morning bathers to take a light lunch before starting for the beach.

The time of staying in the water must depend upon the individual; some people can stay in fifteen or twenty minutes without ill effect, but for most people a five-minute plunge is long enough.

One of the most serious results from sea bathing is inflammation of the ears. No one who has a discharge from the ears should ever bathe in the sea, especially in the surf, and all would do well to stop the ears with a little plug of absorbent cotton before going into the water.

Many people who cannot bathe in the sea are greatly benefited by the sea air and by taking sponge baths, or even tub baths, in salt water in their own rooms every morning. These baths should be followed by brisk rubbing with a rough towel.

body. In winter, they keep in the bodily heat and protect us from cold. In summer, they shield us from the direct rays of the sun.

Clothes should be changed according to the climate or time of year. It is not prudent to leave off winter clothing too early in the spring, for our seasons are most uncertain. Loosely woven, porous material should be worn next to the skin, whether in summer or winter.

We should never allow ourselves to feel cold. If we cannot go where it is warm, or put on warm clothing, we should exercise until we feel warm.

271. Hints on the Use of Clothing. To keep our persons sweet and clean, we must change our clothes often. This not only applies to garments used for daily wear, but to bedclothes and night clothes. No one should sleep in the clothes he wears during the day. Under-garments should be frequently and regularly changed. All bedclothes should be exposed freely to the light and the air.

Young children are less able to resist cold and sudden changes than grown-up people, hence great care must be taken with their clothing. The legs and chests of children should not be unduly exposed to the bitter blasts of winter nor the cold east winds of spring. Many children die every year from lung diseases due to ignorance or neglect in this matter.

272. Plain Advice on the Use of Clothing. Never wear wet or damp clothes longer than is necessary. If you have on wet clothes, take the shortest way home, rub down thoroughly, and put on dry, warm garments.

Do not let your damp skirts, underclothing, wet stockings or shoes dry on you, but always change them at once if possible. Neglect of this precaution is a fruitful cause

of rheumatism, neuralgia, and chest ailments, especially among young people who are careless, ignorant, or indifferent in matters of health.

Do not wear the clothing too tight, and thus allow it to interfere with free movements and easy, graceful carriage, to say nothing of health. The improper use of corsets often crowds important organs out of place and retards their growth. Garters worn below the knee are apt to hinder the circulation, and cause cold feet and sometimes enlarged veins.[1]

273. Additional Hints on the Use of Clothing. Dresses and skirts should never drag their full weight from the hips, but should be partly supported from the shoulders. Health and comfort should not be sacrificed to a desire to dress in a slavish submission to fashion.

Children, and older people too, should never run outdoors without proper covering for the head. Pupils should not be allowed to sit in the schoolroom with outside garments on, such as scarfs, coats, rubbers, and leggings.

[1] Many people, otherwise neat in matters concerning their personal health, will come in from a long, hot, and dusty journey, remove a warm, perspiration-soaked dress or coat, and hang it at once in a close, dark closet, or place in the same receptacle a skirt that has been for hours gathering up the filthy sweepings of streets and cars. It is no wonder that the average wardrobe should give out a most disagreeable odor when the door has been closed for a short time.

All outer clothing, especially if of woolen material, should be hung up in a current of fresh air to dry and cool before being put away. Dress shields, the linings of women's collars, and the bindings of skirts should be often renewed.

The habit of giving a hasty brush to the bottom of a skirt in the house — too often in the bedroom — is uncleanly and may be dangerous. Skirts, even when they are not allowed to sweep the pavements, cannot fail to be laden with dust mixed with bacteria which may cause disease. The same thing is true, to a less degree, of other garments.

THE KIDNEYS

274. Getting rid of Waste Matters. Our bodies are never the same for a single moment. With every breath and with every beat of the heart they are ever changing. Wear and waste vie with growth and repair.

We eat food to supply the bodily engine with fuel, and breathe in oxygen to feed the furnace fire. With a steady burning, but without light, this engine produces not only motion and heat, but uses a part of its own energy to make its own repairs. Not this alone, but it even gets rid of its own soot and ashes, which would otherwise clog the machinery, and finally stop it.

We have already learned that the ceaseless blood current which carries fresh fuel to the tissues, in the shape of the nutrient part of food, is also a kind of sewer stream that rids them of waste matters.

In other words, the blood is ever being made rich by some things, and is ever getting rid of other things. The blood carries fuel to the tissues of the body. In the tissues a slow burning, or oxidation, takes place: the waste or ashes must be got rid of.

275. Principal Waste Matters of the Body. What are these waste matters? If we take a piece of beef, dry it, and burn it, we shall find that it is changed into four things, — water, carbon dioxide, ammonia, and ashes. Now, this slow burning of our tissues is really the same thing.

Hence, in whatever way our bodies are burned, or oxidized, — whether consumed in a furnace or buried in the ground, or oxidized while they are living, — the end is always the same: **water, carbon dioxide,** a kind of ammonia called **urea,** and a small quantity of **salts,** or ashes.

276. The Waste Matters described. Besides the **water** which comes from the food we eat, we drink a great deal of it as plain water. We need to keep the tissues continually moist to help to dissolve the food, and also to flush them and cleanse them of their useless matters and impurities. As we wash the surface of the body to keep it clean, so nature is ever bathing our tissues to wash away their impurities.

The red blood corpuscles, as we know, are the tiny boats which carry the oxygen breathed in by the lungs along the blood stream to every tissue. The tissues contain carbon, which in some mysterious way unites with the oxygen, forming **carbon dioxide.**

The tissues, especially the muscles, yield nitrogen. A compound of nitrogen, called **urea,** is filtered out of the body, through the kidneys. It is a peculiar substance, something like ammonia only more complex.

277. The Chief Organs of Excretion. The process by which the body gets rid of its waste material is called **excretion,** meaning separation from, or sifting out.

The chief organs of **excretion,** or the three main channels by which the waste products leave the body, are the **skin,** the **lungs,** and the **kidneys.**

The functions of these three organs are closely allied. They differ very much in appearance, but are built on the same general principle. The blood, as it passes through the numberless capillaries in these organs, is purified by a sifting process. The waste matters are, as it were, sifted from the blood, and finally removed from the body.

The structure of the **skin** has already been described. One function of the skin, as we have seen, is to rid the body of water and other matters in the form of sweat.

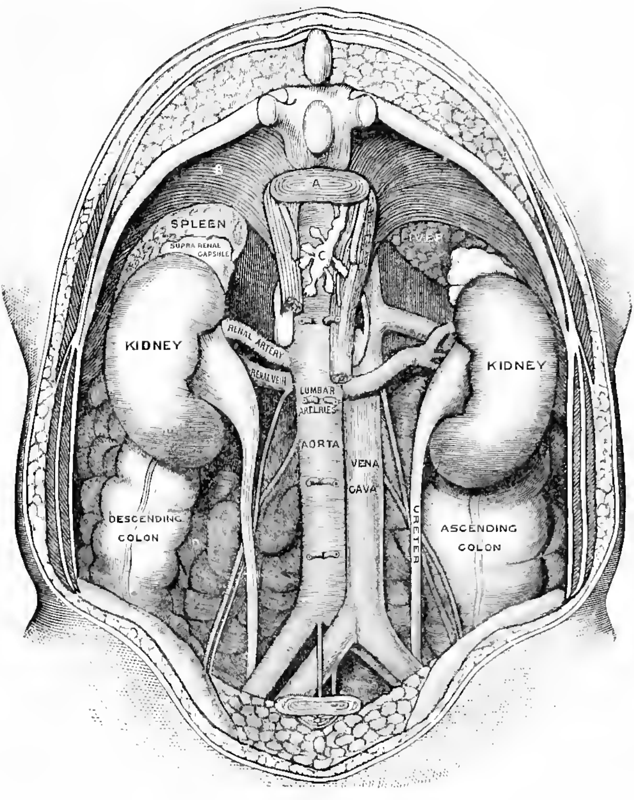

FIG. 128. Vertical Section of the Back. (Posterior view.)

The spinal column below the twelfth dorsal vertebra at *A* has been removed, as well as the various layers of the great muscles of the back. The two kidneys with the renal arteries and veins are plainly shown, in their normal positions. The relative positions of adjacent vessels and organs with their names printed upon them are also shown. *B*, portion of the diaphragm on the left side; *C*, receptaculum chyli; *D*, a part of the small intestine on the left side.

The **lungs** have also been described in a previous chapter. One duty of the lungs, as we have learned, is to excrete carbon dioxide, watery vapor, and a small quantity of other wastes.

278. The Kidneys. The **kidneys,** two important organs of excretion, are of a brownish-red color, about four inches long and two inches wide, and of the shape of a kidney bean. They lie in the region of the loins, in front of the backbone, behind the intestines, one on each side, and are imbedded in fat. A sheep's kidney is a familiar sight in a market. It is very much like the same organ in man.

279. The Structure of the Kidneys. The kidneys are made up of bundles of long tubes, not so very unlike sweat glands. These tubes are surrounded by a meshwork of capillaries. They are very fine, threadlike structures, not more than a five-hundredth of an inch in diameter. Thus, there are thousands upon thousands of them packed together in each kidney.

The blood filters certain waste matters dissolved in water into these tubes, just as it gives up sweat to the sweat glands. These tubes unite into one common duct from each kidney, which carries away the excretion. In due time this waste material is cast out of the body.

The kidneys thus serve as a peculiar and delicate kind of filter, carrying off **urea, inorganic salts,** and other waste matters dissolved in a large quantity of **water.**[1]

280. The Work done by the Kidneys. About three pints of fluid are daily discharged, on an average, through the

[1] The whole of this excretion is called the **urine.** It is in reality water, holding in solution urea and several salts. The urine is constantly being secreted by the kidneys. It is carried to the bladder, which serves as a reservoir. It collects in the bladder until this receptacle is nearly full, when it is emptied by the contraction of its walls, aided by the abdominal muscles.

kidneys, and a little over one ounce of urea. Out of the body, the urea soon changes into carbon dioxide and ammonia.

Besides urea, the kidneys also serve to carry off each day almost an ounce of various mineral substances that are either foreign to the body or are present in the blood in too large a proportion, — for example, common salt.

If the kidneys are inactive or fail to excrete the nitrogenous waste matters, the work of many other organs is seriously impaired. The blood is poisoned, and death may result from the poisonous material which is retained in the tissues.

281. The Health of the Kidneys. The kidneys are very busy organs. Their health is a matter of prime importance.

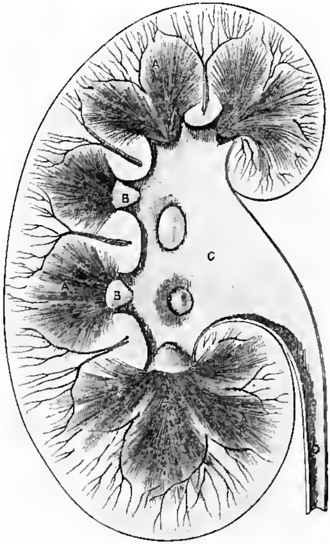

FIG. 129. Vertical Section of the Kidney.

A, pyramids of the kidney; *B*, apices, or papillæ, of the pyramids; *C*, pelvis of the kidney; *D*, upper end of ureter.

We have already become familiar with the hygiene of two great organs of excretion, — the **skin** and the **lungs**.

These three sets of organs, working together in harmony, like three groups of mechanics doing some difficult work, keep the bodily machinery from getting clogged and choked with waste matters.

If the free action of the skin or the lungs is interrupted, the kidneys have extra work to do. They make every effort

to do the additional work that is thrown upon them; but, sooner or later, they fail under the burden, and become diseased.

282. Effect of Alcohol upon the Skin. As we have already learned in previous sections, the paralyzing action of alcohol results in a dilatation of the arteries and the capillaries. Now, it is evident that the skin, like any other active organ, depends for its nourishment upon the proper circulation of the blood. Hence, if this circulation is interfered with, the skin lacks its chief element of vitality.

The flushed and warm face, so often noticed after taking a very moderate amount of alcoholic liquor, is due to the temporary dilatation of the capillaries in the skin. If the use of alcoholic beverages is continued for a long period, this dilatation of the blood vessels becomes permanent. The tiny capillaries about the face are often seen running their crooked course just under the skin of the nose and the cheeks.

The skin, as we know, is the chief regulator of the loss of heat from the body. When we drink alcoholic liquors, more blood is carried to the surface and more heat passes by radiation from the skin into the cold air. Thus, heat which is needed elsewhere, especially in cold weather, is lost. In other words, the surface of the body is warmed at the expense of its vital organs within.

The skin also plays an important part in the excretion of waste matters. If the circulation of the skin is disturbed, as it is by alcohol, so that it is unable to do its portion of work in the process of excretion, more work is required of the kidneys. These important organs are then overworked, resulting in more or less disturbance of the general health.

283. Effects of Alcohol upon the Kidneys. The kidneys differ from some other organs which can rest awhile without any harm to the body. For instance, we can keep the eyes closed for a few days, if necessary, without injury, and in fact often with benefit; or, we can abstain from food for some days, if need be, and let the stomach rest. But the kidneys cannot, with safety, cease their work even for one hour. Their duty in ridding the blood of waste products and of any foreign or poisonous material introduced, must be done continually, or the general health of the whole body is disturbed.

Thus it is, as we may well suppose, that these two important organs, with their large blood vessels conveying enormous amounts of blood to and from their tissues, feel very quickly the presence of alcohol. Alcoholic liquors tend to irritate the delicate kidney tissues and thus speedily disturb their work of excreting the waste materials from the blood.

The continued congestion of the kidneys may result in a series of disturbances from the imperfect elimination of waste matter. The urea, which is a poison and which must be removed, may be retained in the system, while the albumin, which is essential to healthy blood, may be filtered away through the overtaxed kidneys.

The long-continued use of alcohol may produce such a change in the structure of the kidneys that fat cells become infiltrated into the tissues, causing in them what is known as fatty degeneration.

QUESTIONS ON THE TEXT

1. Give a general definition of the skin. 2. What purpose does the skin serve? 3. Of what two layers is the skin composed? 4. Describe in some detail the scarfskin. 5. What gives the color to the skin? 6. Describe briefly the dermis, or true skin. 7. What are the papillæ? 8. How may the skin absorb various kinds of poison? 9. Give some of the more common ways in which the absorption of poisons by the skin may take place. 10. Describe the structure of a hair.

11. How does the hair grow? 12. What gives the color to the hair? 13. Describe the muscles with which the skin is provided. 14. What are the nails? 15. Describe the structure of the nails. 16. Give some practical points about the care of the nails. 17. What are oil glands? 18. What purpose do the oil glands serve? 19. In what parts of the skin are the oil glands found? 20. Describe the sweat glands.

21. What is sweat, or perspiration? 22. What is the most important function of the perspiration? 23. Explain in some detail why we should take proper care of the skin. 24. For what two reasons are baths taken? 25. Give some practical hints about bathing in cold water. 26. Why should we take good care of the hair? 27. What useful purpose do our clothes serve? 28. Give a few practical points on the use of clothing. 29. What plain advice can you give about clothing? 30. What other points about clothing have you learned from the text?

31. Explain briefly how our bodies get rid of waste matters. 32. What part does the blood play in these changes? 33. What are the chief waste matters of the body? 34. What is meant by excretion? 35. What are the three chief organs of excretion? 36. What do the skin and the lungs excrete? 37. What are the kidneys? 38. Describe the structure of the kidneys. 39. What can you say of the work done by the kidneys? 40. Show how the three great organs of excretion should work in harmony. 41. Give briefly the effect of alcohol upon the skin. 42. What is the effect of alcoholic liquors upon the kidneys?

CHAPTER X

THE NERVOUS SYSTEM

284. All Parts of the Body work together in Harmony. In the preceding chapters, we have learned that each organ not only looks after itself, but is ever ready to come to the help of other parts of the body. Everywhere we find organs working together for each other's good. Strike suddenly at the eye, and the lids fall to protect it. Tickle the foot, and the muscles of the leg contract and pull it away. When the skin is inactive, the kidneys come to its help.

Fifty skilled mechanics might do their best at building a vessel or a house, but if each man worked as he pleased, and took no heed of the rest, the result of their work would be of little account. The master builder must be at his post, skillful to direct and quick to act. So it is with our bodies. The wonderful agency which governs every organ of the body is the **nervous system.**

285. The Nervous System compared to a Telegraphic System. The nervous system may be aptly compared to a complete telegraphic system. The brain and the spinal cord are the main offices; and the nerves, branching off to all parts of the body, are the telegraph wires. The brain and the spinal cord together are called the cerebro-spinal center. Dispatches are constantly being sent to the cerebro-spinal center to inform it of what is going on in various parts of the body. The cerebro-spinal center, on

receiving the news, at once sends back its commands as to what must be done. In brief, countless dispatches are sent to and fro with wonderful rapidity and unerring precision.

Thus, if we accidentally pick up a hot coal, we drop it instantly. A nervous impulse or message is sent from the nerves of touch in the fingers to the cerebro-spinal center, which hurries off its orders to the muscles of the fingers to drop the burning coal.

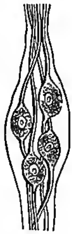

FIG. 130. Nerve Cells from the Spinal Cord.

286. Nerve Cells and Fibers. Nerve tissue is really made up of a great number of distinct units called **nerve cells.** Each cell usually contains a large nucleus and gives off one or more tiny branches, or processes. These cells vary more in shape and size than any other cells in the body. Each nerve cell has a number of short branches, and many have also one long branch which can be traced for some distance from the cell body. This rootlike process is called an **axis cylinder.** This is the beginning of a **nerve fiber.**

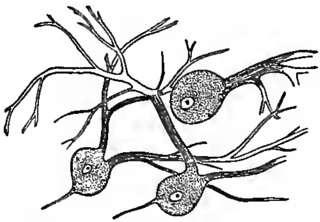

FIG. 131. Nerve Cells from the Gray Matter of the Brain.

In most fibers a layer of white, fatty substance, called the **medullary sheath,** protects this soft, gray central core, the **axis cylinder,** as a kind of insulating material, just as electric wires are sometimes covered with waxed paper or thread to prevent the escape of the current. Outside of this is another transparent sheath, or covering, called the **neurilemma.** Some fibers lack the white medullary sheath.

Nerve fibers may be only the smallest fraction of an inch in length, or they may be several feet long. Thus, there are nerve fibers which run from the spinal cord to the tips of the toes. The axis cylinders end in branches running to muscle fibers, to glands, or they may end in contact with sense cells in a sense organ.

Wherever the nerve cells are abundant, the nerve tissue has a gray color; in other places, it looks white. Most of the gray matter of the brain is on the surface. In the spinal cord, the gray matter lies within the white matter, presenting, in section, a crude outline of the letter H (Fig. 140).

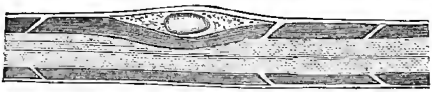

FIG. 132. Portion of a Medullated Nerve Fiber.

The axis cylinder is in the center. On either side is seen the medullary sheath, represented by dark lines. The primitive sheath, or neurilemma, is on the outside and represented by white lines in which is a nerve corpuscle with an oval nucleus.

287. Work done by Nerve Cells and Nerve Fibers. The **nerve cells** are highly active masses of living matter which are nourished by material brought to them by the blood.

The **nerve fibers** are conductors of nervous impulses or messages. They serve, not unlike telegraph wires, to connect remote parts of the body with central nerve stations.

Experiment 64. *To show the structure of the nerves.* Take a small piece of a nerve, which may be easily obtained from the market. Tease it lengthwise with needles on a glass slide. With a hand lens, or even with the naked eye, the nerve is seen to be made up of silky threads.

Take one of the threads and fray it out as finely as possible on a clean slide. Add a drop of saline solution, and examine under the high power of the microscope. The nerve fibers are now seen as exceedingly slender, white threads with a well-marked wavy outline.

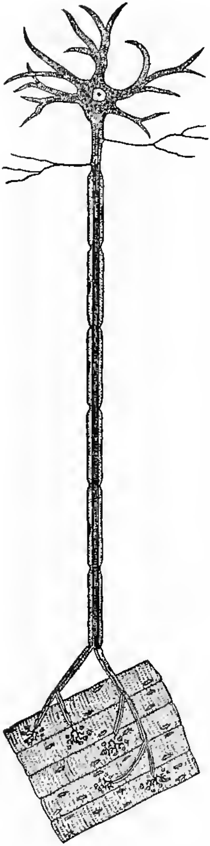

FIG. 133. Diagram of a Neuron, or Nerve Unit.

Showing a motor cell with its long, unbranched process (with two little lateral offshoots), with motor endings in striated, voluntary muscular tissue.

288. Structure of the Nerves. If we take a small piece of a nerve from a dead rabbit or frog, and with needles separate it lengthwise on a glass slide, we find it can be pulled apart into bundles of silky threads. If these threads are frayed out as finely as possible, the high power of the microscope reveals still smaller threads or fibers. It would take about four thousand average-sized nerve fibers to cover an inch when placed side by side.

The nerve fibers bound together in cords of various sizes form the **nerves.**

289. General Arrangement of the Nervous System. The nervous system consists of two great sets of nerves and nerve centers which are intimately related, and yet for convenience may be studied apart.

These are the **cerebro-spinal** system and the **sympathetic** system.

The **cerebro-spinal,** or central nervous, system consists of the **brain** and the **spinal cord,** together with the **nerves** which branch off from each.

The **sympathetic** system consists chiefly of a double chain of **ganglia,** or knots of nerve cells, lying at the sides and in front of the **spinal**

column, and connected with one another and with the central nervous system by nerve fibers (Sec. 304).

290. The Brain. The **brain** fills the entire cavity of the skull, and consists of a number of separate masses of nerve matter abundantly supplied with blood vessels (Fig. 98).

The brain is the organ of the mind; in other words, it is the seat of consciousness, the intellect, the memory, the will, the affections, the emotions, and sensation.

The brain controls all voluntary motions.

291. The Weight of the Brain. The average weight of the human brain is about fifty ounces, or about three pounds.[1] A few cases have

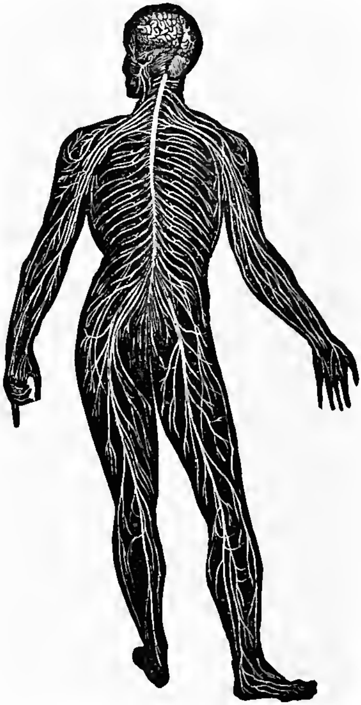

FIG. 134. Diagram illustrating the General Arrangement of the Nervous System. (Posterior view.)

[1] The brain of Oliver Cromwell is said to have weighed eighty ounces. Daniel Webster's brain weighed fifty-three and a half ounces, and Ruloff's — a notorious murderer, but in some respects a very learned man — fifty-nine ounces. The brain of Cuvier, the celebrated naturalist, weighed sixty-four and a third ounces; and that of Dupuytren, a famous French surgeon, sixty-two and a half ounces. The hats of ten gentlemen were tried upon the skull of Robert Burns, and the only one of the ten that could cover it was the hat of Thomas Carlyle. An idiot's brain is usually small, rarely exceeding thirty ounces.

been noted in men of great mental capacity, in which the brain weighed sixty-four ounces. As a rule, a large brain stands for a vigorous mind and superior faculties.

The brain and head in a child are very large in proportion to the rest of the body. The brain grows very rapidly until the fifth year, then very slowly, and after twenty the growth is not perceptible.

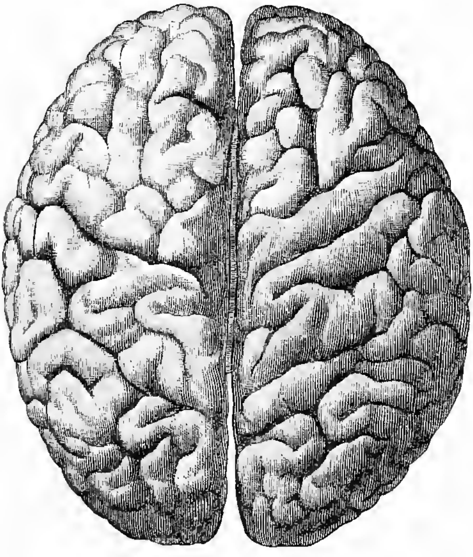

FIG. 135. The Upper Surface of the Cerebrum.

Showing its division into two hemispheres, and also the convolutions.

292. The Three Parts of the Brain. The three principal masses or parts which make up the brain are: (1) the **cerebrum,** or brain proper; (2) the **cerebellum,** or lesser brain; (3) the **medulla oblongata.**

293. The Cerebrum. The **cerebrum** fills the whole of the upper part of the skull, and is nearly seven eighths of the entire mass. It consists of two parts, or halves, almost separated from each other by a deep cleft, or fissure, from front to back. Each of these halves — or **hemispheres,** as they are called — consists of three portions, or **lobes,** so that the cerebrum is made up of six distinct parts.

294. The Convolutions of the Cerebrum. The cerebrum has a peculiar folded-up appearance, its various folds — or **convolutions**, as they are called — being separated by deep

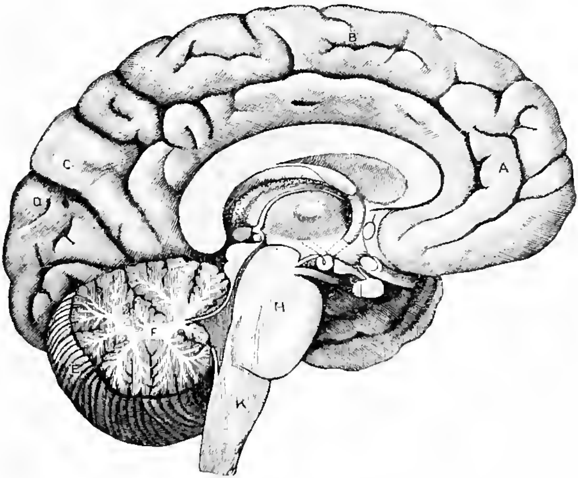

FIG. 136. The Left Half of a Vertical Median Section of the Brain.

A, frontal lobe of the cerebrum; *B*, parietal lobe; *C*, parieto-occipital lobe; *D*, occipital lobe; *E*, cerebellum; *F*, arbor vitæ; *H*, pons Varolii; *K*, medulla oblongata.

clefts, sometimes nearly an inch deep. In this simple way the surface of the brain is increased many fold. The cerebrum is made up of both white and gray matter.

The interior of the brain is made up chiefly of the white nerve substance just spoken of, and also important masses of gray matter called **ganglia**. The gray matter is the outer layer, about one eighth of an inch in thickness, and is spread over the white substance somewhat like a silk handkerchief which has been crumpled up.

The active powers of the mind are supposed to reside in this outer layer of the brain. These powers are great or small, according to the number and the extent of its folds, or convolutions. In the lowest vertebrate animals the brain has no folds; but as we pass to animals of a higher grade, the folds begin to appear.[1]

295. The Cerebellum. The **cerebellum,** or little brain, lies beneath the back part of the brain proper. It is made up of two halves, each formed of a number of layers of gray and white nerve matter, curiously arranged. These masses resemble somewhat, in section, the branches of a tiny tree and hence are fancifully called "arbor vitæ" (Fig. 136).

The functions of the cerebellum are not yet certainly known. It appears to aid in the control of the muscles of the body; that is, it serves to bring the various muscular movements into harmonious action.

296. The Medulla Oblongata. The **medulla oblongata** is the thick continuation of the spinal cord lying within the cavity of the skull. It is just under the little brain, and makes the connecting link between the brain and the spinal cord. It is a highly important part of the brain, since from it arise important nerves which regulate breathing, swallowing, the heart's action, and other vital processes. If this part of the brain be broken or cut, respiration and circulation will at once cease, causing instant death.

[1] The brain is inclosed within three distinct membranes, — the **dura mater** (hard mother), the **arachnoid** (like a spider's web), and the **pia mater** (delicate mother).

The dura mater is the tough membrane which lines the inner surface of the skull and forms a loose outer covering for the brain. The middle layer, called the arachnoid, secretes a fluid which keeps the inner surface moist. The pia mater is a very delicate membrane which dips down between the folds of the cerebrum.

Experiment 65. *To show the brain.* Get a sheep's brain from the butcher. Pay him to dissect away the skin and muscles of the skull, under your direction, and to saw open the cranium in such a manner as to expose the entire upper surface of the brain. Remove the sawed top and carefully tear off the dura mater from the bones.

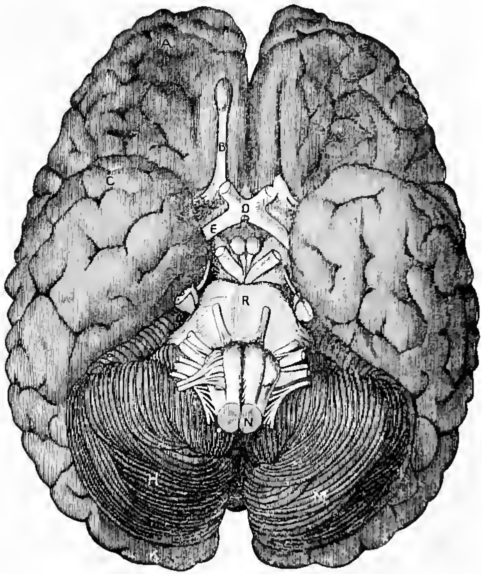

FIG. 137. The Base of the Brain.

A, anterior lobe of the cerebrum; *B*, olfactory nerve; *C*, portion of the posterior lobe; *D*, optic chiasm; *E*, optic tract; *H*, *M*, hemispheres of the cerebellum; *K*, portion of the occipital lobe; *N*, medulla oblongata; *R*, pons Varolii. (See also Fig. 98.)

Now cut away enough of this membrane so that the sides of the skull can be sawed and torn away, to allow the brain to be lifted out in fair condition. Put all the torn parts and membranes back into place.

The sheep's brain is very small and not to be compared in size with that of a man, but the general arrangement of the parts is the same.

Note the dura mater, the tough, outer membrane; the arachnoid, the thin membrane which lines the dura mater; and the pia mater, the delicate membrane which is closely attached to the brain. Find the cerebrum, or big brain; the cerebellum, or little brain; the medulla, and the stumps of the cranial nerves (Note, p. 218).

In the cerebellum examine the curious folded arrangement of the gray and white matter forming the arbor vitæ. Cut open the cerebral

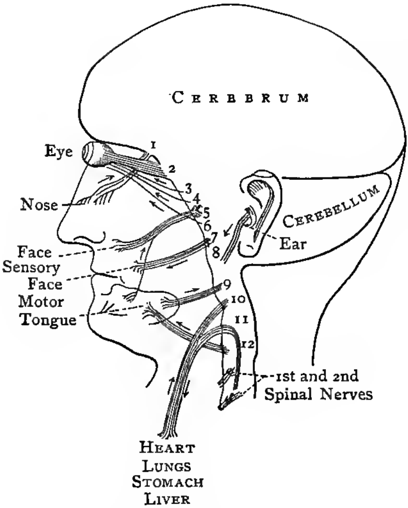

FIG. 138. BLACKBOARD SKETCH.

Diagram of the Distribution of the Cranial Nerves.

The cranial nerves are thus arranged in pairs: 1, olfactory nerves, special nerves of smell; 2, optic nerves, passing to each eyeball, devoted to sight; 3, 4, and 6 control the muscles of the eyes; 5, trifacial in three branches, which proceed mainly to the face, partly sensory and partly motor; 7, facial nerves, controlling the facial muscles; 8, auditory, or nerves of hearing, distributed to the organs of hearing; 9, glossopharyngeal nerves, partly sensory and partly motor: each nerve contains two roots, one a nerve of taste, the other a motor nerve, which controls the muscles engaged in swallowing; 10, pneumogastric nerves (described in Sec. 297); 11, spinal accessory nerves, supplying some of the muscles of the neck and back; 12, hypoglossal nerves, controlling the movements of the tongue in speech and swallowing.

hemisphere and observe the gray and the white matter inside. The brain should be first examined as a whole, and compared with the description given in the text, or with the diagrams of the human brain. With careful dissection and by comparison with diagrams, most of the twelve pairs of cranial nerves can be identified.

NOTE. — A fresh brain is too soft for handling or for careful study. Hence it should be hardened and made ready for use several weeks before it is needed. A mixture of one fourth of an ounce of bichromate of potash and one ounce of a forty-per-cent solution of formalin to about one quart of water makes a useful hardening and preserving fluid.

297. The Cranial Nerves. From each side of the brain proceed twelve pairs of nerves, called **cranial nerves**. They pass out of the skull in pairs through little holes in its base, and supply the

face, the organs of smell, taste, hearing, and sight, and certain internal organs. The cranial nerves are of three kinds, — **sensory**, **motor**, and **mixed**, i.e. combining both.

The tenth pair, called the **pneumogastric** or the **vagus**, the "wandering nerve," is perhaps the most important nerve in the body. It supplies the larynx, the lungs, the heart, the stomach, and the liver. It is partly motor and partly sensory.

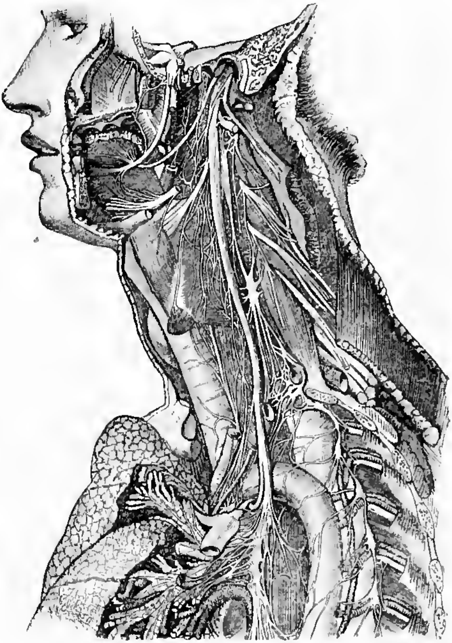

FIG. 139. Trunk of the Left Pneumogastric Nerve.

Showing its distribution by its branches and ganglia to the larynx, pharynx, heart, lungs, and other parts.

298. The Spinal Cord. The **spinal cord** is a column of soft nerve tissue, extending from the base of the skull to the region of the loins, where it tapers into little threads. It is a continuation of the medulla oblongata, and its average length is about eighteen inches.

The spinal cord receives impressions from various parts of the body by means of its sensory nerves, and carries them to the brain, where they excite sensation,

or consciousness. It also sends out, by means of its motor nerves, the commands of the brain to the voluntary muscles.

Experiment 66. *To show the spinal cord.* Get at the market an uninjured piece of the spine of an ox. Cut this across with a sharp knife, and examine it for the following points. The cord is clothed with a vascular membrane, the pia mater, and is composed partly of a white substance lying on the outside, and partly of a pinkish-gray substance lying within. There are two crescentlike masses of gray substance (arranged roughly in the form of an H), lying one in each half of the cord and joined by a narrow bridge of the same material, which crosses the middle of the cord. The white matter surrounds the gray crescents.

The cord is almost divided into halves (exactly similar to each other) by an anterior and posterior fissure. In the middle of the bridge of gray matter there is a little canal, called the "central canal," which runs the whole length of the spinal cord. This canal cannot, however, be seen with the naked eye.

299. Reflex Action of the Cord and Brain. The spinal cord is not merely a bundle of nerve fibers for carrying messages to and from the brain. It also acts as a kind of independent center, receiving messages from certain parts of the body by means of its sensory nerves, and on its own authority sending back orders to the muscles by its motor nerves, without waiting to consult the brain. This is known as **reflex action.**

If one is asleep, and the feet are gently tickled, the legs will be moved out of the way without the sleeper necessarily being awakened. When the spine is broken by an injury, causing pressure upon the cord, all sensation and motion are lost in the paralyzed limbs. But if these paralyzed limbs are irritated, as by pricking the soles of the feet with a needle, then the legs kick out vigorously. The injured person does not feel the pain of the needle, and can exercise no control over the legs. There is no conscious action whatever.

This unconscious motion is the result of reflex action of the spinal cord. It is called reflex because the impression does not go to the brain, but is reflected, meaning turned back again, from the sensory nerves through the motor nerves.

300. Importance of Reflex Action. We rarely stop to think how important reflex action is to our health, comfort, and safety. Because we are able to do hundreds of things

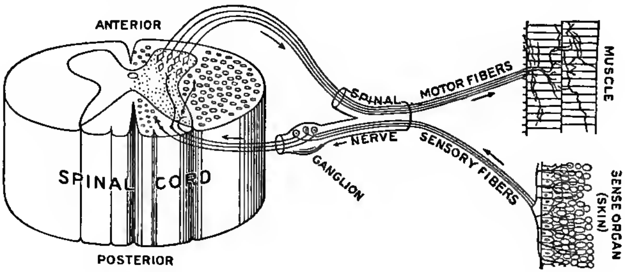

FIG. 140. BLACKBOARD SKETCH.

Illustrating the path of a simple nervous reflex action.[1]

every day without any effort of the will, we are apt to forget its importance. In fact, the greater part of nerve power expended in the body goes to produce these numberless reflex actions.

[1] For illustration, let us note what happens when the tips of the fingers are in danger of being burnt. The organ of sensation in the finger tip sends the impression of pain along the *sensory* fibers (through the ganglion) of the posterior root by means of a long nerve branch to the cells in the posterior horn of the gray matter of the spinal cord. At the cord, the sensation may go to the brain, or instead it may at once pass to the anterior horn of the gray matter of the cord. Thence the impulse is sent forth along the *motor* fibers to the muscles of the arm. The muscles promptly contract, and the fingers are jerked away from the irritating object even before the brain knows what is taking place.

We are not so independent in our daily actions as one would at first think. Ten thousand unconscious acts take place which tend to govern and preserve our health. We have as little control over them as we have over the stars above us.

301. Familiar Examples of Reflex Action. Let us call to mind a few familiar examples of reflex action. If our feet slip on the ice, without the effort of the will the body tends to recover itself. The mind does not always act, at least in the ordinary way, to pull the fingers away when they touch a hot stove. We try to brush the flies away when we are asleep.

FIG. 141. Dental Branch of One of the Divisions of the Fifth Pair of Cranial Nerves, supplying the Lower Teeth.

Branches from the motor root, distributed to various muscles, are also shown.

By an effort of the will, we can stop our breath for a moment or two; but soon the call for air is imperative, and the order must be obeyed, whether we will or no. The great work of digestion is going on day after day, but we have no control over its complicated movements.

Experiment 67. *To illustrate reflex action.* Tickle the inside of the nose with a feather. This does not interfere with the muscles of breathing, but by reflex action they come to the help of the irritated part, and provoke sneezing to clear and thus protect the nose.

302. How Reflex Action gives Relief to the Brain. Reflex action relieves the "thinking centers" of the brain of a vast amount of work. If we were forced to use our will power at every step in the process of digestion, the brain would be put to a severe strain. We could not eat, and then quietly go about our business. If we had to plan and will every heart beat, we should soon be ready to give up the struggle for life.

If we had to exert our will every time we breathed, we should soon get tired of it, and long to die. We could never sleep, for the brain would have to be on the alert to decide if it were time for the next heart beat, the next inspiration, and the proper time for each digestive fluid to flow.

303. The Spinal Nerves. From the spinal cord thirty-one pairs of **spinal nerves** proceed to the trunk and the limbs. They pass out on each side of the spinal canal through small openings at the sides of the backbone.

Each of these spinal nerves has two roots, — one going from the front part, and the other from the back part, of the cord. These two roots unite and form one silvery cord as they pass out from the backbone (Fig. 140).

The root which goes from the front, or **anterior,** part of the spinal cord consists of **motor fibers** and controls muscles.

The root which comes from the back, or **posterior,** part of the cord consists of **sensory fibers** and transmits sensations from the various parts of the body to the spinal cord.

As each nerve trunk leaves the backbone, it subdivides and sends off branches into all parts of the body. Each branch contains fibers from both roots. If any one of these nerves or branches is cut or injured, the power of feeling and movement ceases in all those parts to which it is

distributed, — that is, those parts of the body are paralyzed. The case is not unlike that of cutting a telegraph wire, and thus stopping the passage of the electric current.

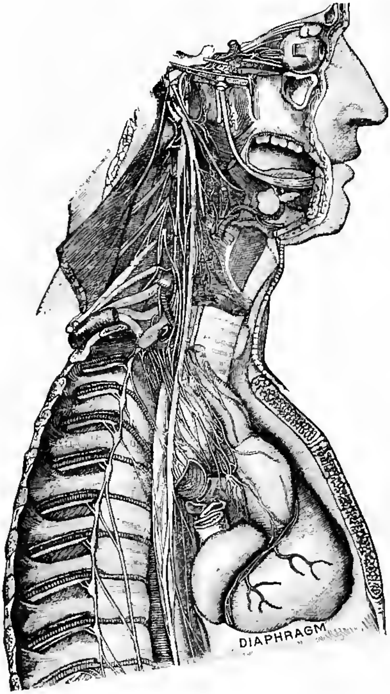

FIG. 142. The Cervical and Thoracic Portions of the Sympathetic Nerve and their Main Branches.

In the center of the figure, running almost vertically, is shown the right pneumogastric nerve. To the left may be seen a chain of ganglia of the sympathetic nerve, running along the vertebrae. The distribution of some smaller ganglia and nerve branches in the neck and chest regions are also shown.

304. The Sympathetic Nervous System. The **sympathetic nervous system**,[1] as we have learned (Sec. 289), consists of a double chain of nerve knots, or **ganglia**, connected by nervous cords running down in front and on each side of the backbone.

The knots of nerves are connected with each other, and with the spinal nerves, by a network of nerve fibers.

Through the sympathetic ganglia, nerve fibers from a part of each spinal nerve pass on their way to important internal organs. A close network of the

[1] The name "sympathetic" was given to this part of the nervous system because it was believed that, through its agency, distant organs have sympathy with one another's afflictions.

sympathetic nerves is formed upon the heart, and about the lungs, the stomach, and the intestines, as well as around the walls of the minute arteries and capillaries.

A large part of the regulating action of the vital organs is controlled by the influences which thus reach these organs through the sympathetic nerves.

305. How the Sympathetic System acts. It is believed that the sympathetic nerves do not serve as independent nervous centers. The influences which they convey to the great processes that are beyond the control of the will, are derived from the brain or the spinal cord.

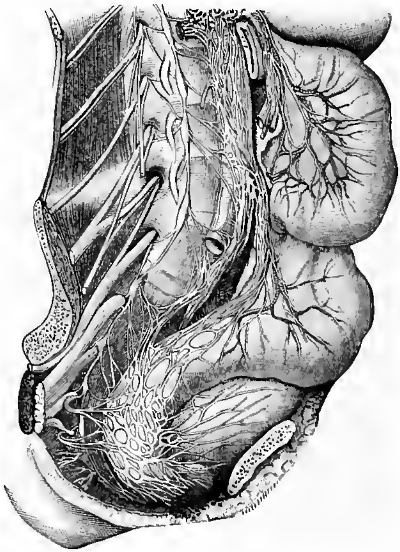

FIG. 143.

Showing the distribution of some of the great plexuses of the sympathetic nerve in the lumbar and sacral regions.

Therefore we may think of these great networks, or **plexuses**, of nerves, not as a separate nervous system, but as **an outlying part of the cerebro-spinal system.** The sympathetic nerves are very slow to act. A blush steals slowly up to the roots of the hair. If we go from the dark into a strong light, we are blinded. The pupil of the eye is too large. An impression is made on the sympathetic nerve, which causes it to contract slowly while we are shading our eyes.

306. The Health of the Nervous System. The health of every organ of the body is dependent upon the welfare of the nervous system.

If a tiny blood vessel in the brain is broken and forms a little clot as large as a pea, a paralysis of one side may be produced by its pressure on the delicate brain tissue. An overloaded stomach may make the brain dull and stupid for some time. Indigestion may make one cross, morose, and unhappy. The long loss of sleep may cause exquisite suffering.

A slight blow on the head may instantly rob a man of consciousness. On the other hand, severe accidents to the brain may not produce serious results. By breathing in such poisons as ether or carbonic acid gas, the blood is so altered that the brain ceases to act and consciousness vanishes.

307. Brain Power increased by Education. Like any other organ, the brain may be strengthened and increased in its power by education. Impressions made upon the mind in early life are more readily received and more completely retained than those which are made when the growth of the brain is far advanced. For this reason, education should be begun early in life; and educational influences brought to bear at that time are most effective in shaping mental growth. It is an object for which most parents are willing to work hard and to exercise much self-denial.

308. Worry and not Mental Work overtaxes the Nervous System. Just as the stomach may be overworked and fail after a time to digest food properly, and as muscles are exhausted by overexertion, so may the nervous system, especially the brain, be overtaxed.

Mental work is rarely hurtful to a healthy person who takes good care of himself. It is not so much severe

mental toil as it is worry that disturbs the mental poise. It is not study, but fretting, that causes the student to break down in his studies. Let young people have plenty of nutritious food properly given, plenty of sound sleep, enough suitable clothing, and a calm and wise oversight at home, and they will rarely be injured by too much study.

It is fretting about passing examinations, worrying about promotions, and other baneful influences, which have become attached to our educational system like barnacles to a stately ship, that may make the delicate, sensitive child cross, peevish, and sickly.

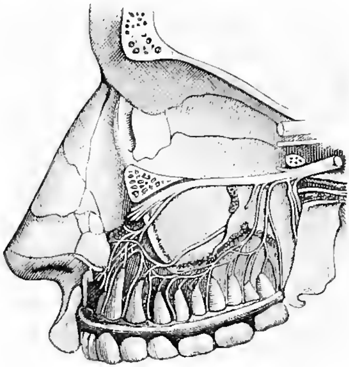

Fig. 144. Dental Branches of One of the Divisions of the Fifth Pair of Cranial Nerves, supplying the Upper Teeth.

309. Abuse of the Nervous System. Every tiny cell of the nervous system is busily at work doing its allotted duty. Now, let a person fret and worry day after day over real or fancied troubles, abuse his digestive organs by too much or too little food, go without proper sleep, smoke or chew tobacco in excess, try to prop up his flagging energies with strong coffee or alcoholic liquors, and the strain on the nervous system will make him, sooner or later, a mental wreck.

Like a spendthrift who spends his principal and persists in calling it his income, so is a man who is indulging in various forms of dissipation really exhausting the limited amount of nervous force at his command. Unhealthful and

injurious habits, whether in the important or the comparatively trifling matters of daily living, are drafts drawn on the future, which must be met at no distant day with all the attendant perils of physical or mental bankruptcy.

310. The Importance of Sleep. The need of **sleep** is self-evident, and the loss of it is one of the more common causes of ill health. The muscles and the nerves, the brain in particular, are in full activity when we are awake. Repair goes on every moment, whether we are awake or asleep. During the waking hours, however, the waste of the tissues is in excess of the repair, while during sleep the repair exceeds the waste.

Hence the good mother, nature, at regular intervals, causes all parts of the bodily machinery to be run at their lowest pressure. In other words, we are put to sleep.

311. Rest of Important Organs during Sleep. During sleep the heart beats, the lungs take in air, and the stomach digests its food; but these great organic processes are carried on but feebly. The vital organs rest because they are worked at their lowest rate.

The eye, the ear, the brain, and the nerves are rested by darkness, silence, and unconsciousness. The tired muscles thus regain their vigor and the exhausted brain is refreshed.

Sleep is more or less sound according to circumstances. Fatigue, if not too great, aids it; while idleness lessens it. Anxious thought and pain and even anticipated pleasure may prevent it. The sounder the sleep, the more the body and the mind are refreshed.

312. Hints about Sleep. The best time for sleep is at night. The soundest and best sleep is obtained during silence and darkness. People who are forced to work at night and to sleep during the day usually have a strained and wearied look.

The amount of sleep necessary depends upon our occupation and our temperament. Some require little sleep, while others need a great deal. Eight hours of sound sleep for a grown man or woman, and more for children, is about the average amount required. Children naturally need more sleep because their bodies need more rest during the period of growth. Hence the infant sleeps most of the time, if well and properly cared for.

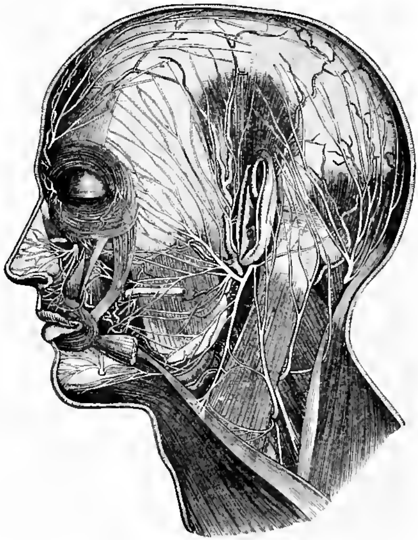

FIG. 145.

Showing some of the superficial nerves on the left side of the neck and the head. A few superficial muscles and arteries in the same region are also shown.

Little children should always be put to bed early and allowed to sleep in the morning until they awake of themselves. During hot weather the active child should be undressed, bathed, and put to bed in the middle of the day for a good nap. Do not go to bed with the brain excited or too active. Read some pleasant book, talk quietly, sing, take a brisk walk, or otherwise indulge in a little quiet recreation for half an hour before going to bed.

313. Some of the First Effects of Alcoholic Liquors upon the Nervous System. The first symptom which shows that the nerves are disturbed by drinking alcoholic liquors is the

quickened action of the heart, and with it the dilatation of the blood vessels. The face is flushed and there is a glow over the skin, because the nerves which regulate the size of the blood vessels are partially paralyzed by the alcohol.

The tiny blood vessels of the brain are dilated and the nerve cells are stimulated. The brain may become more active, thoughts flow more rapidly, and the speech become more fluent; but such activity is only an indication of a disturbance of the natural conditions of the body. The power of right thinking is diminished, and the fluent speech in a short time tends to become lacking in good sense.

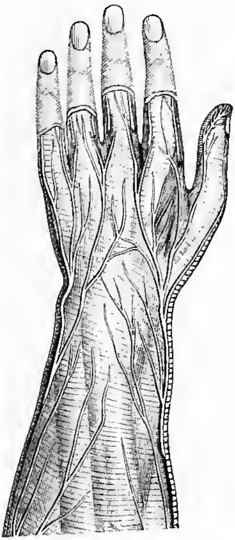

FIG. 146. Superficial, or Cutaneous, Nerves on the Back of the Left Forearm and Hand.

The parts of the brain used in the higher processes of thought and reasoning seem to be the most delicate and therefore most easily injured. Investigation has shown that it is these delicate parts of the brain which are first injured by alcohol. Thus, the common observation that alcohol impairs first the higher functions of the mind finds its confirmation and explanation in discoveries made by the microscope concerning the changes which alcohol may cause in the actual structures of the brain.

The effect of wine sometimes seen at a social dinner where those who have taken moderate amounts begin to grow talkative, excitable, and hilarious represents an unnatural state of the nervous system. Such persons are really in the first

stage of intoxication, which is that of mental excitement. This brief period of excitement is usually followed by the depressant or narcotic action of alcohol. It is incorrect, therefore, to call that which produces progressive paralysis of the center of the nervous system, both sensory and motor, a stimulant.[1]

314. The Power of Self-Control weakened by Alcohol. The power of self-control, which is the most difficult of the human faculties to acquire, and the last to be fully attained, is the first to be weakened by alcohol. In this fact lies the danger of the use of alcohol as a beverage. For example, some men intend to take only one drink on some social occasion; but that one drink so weakens their mastery of themselves that they drink glass after glass. Others set out to use alcoholic drinks moderately every day; but usually as time passes they allow themselves increasing limits. Self-control weakens under the repeated contact of alcohol with the brain cells.

This is the history of practically every drunkard; while the example of those who drink but do not become drunkards leads astray thousands of others whose nervous systems

[1] Helmholtz, at the celebration of his seventieth birthday, spoke of ideas "flashing up from the depth of the unknown soul" that lies at the foundation of every truly creative intellectual production, and closed his account with these words: "The smallest quantity of alcoholic beverages seems to frighten them away."

Some people imagine that after the use of alcohol they can do things more quickly, that they are brisker and sharper, but exact measurement shows that they are slower and less accurate. Men believe that they are wiser and brighter, but their sayings are more automatic and apt to be profane. To quote T. Leander Brunton, M.D., of London, England, "It produces progressive paralysis of the judgment," and this begins with the first glass. Men say and do, even after drinking a single glass of liquor, what they would not say or do without it, and therefore it clearly affects the brain and diminishes self-control. — G. Sims Woodhead, M.D.

are more quickly injured by alcohol or whose conditions in life are less favorable for resisting its effects.[1]

315. The Next Step. Smaller quantities of alcohol than those usually considered moderate can be shown, by fine tests, to weaken self-control. If more is taken, there gradually follows loss of power over some of the muscles, and the energy of the whole muscular system is lessened. The muscles of the lower lip and the legs are the first to feel this unnatural torpor. The speech is thick and the gait uncertain.

The nerve cells of the higher, or controlling, part of the brain may soon be brought within the grasp of the alcoholic influence, and the faculties of the mind are still more impaired. Reason is off duty, and the lower, or animal, impulses begin to manifest themselves. First, the control of judgment and the will disappears, and the emotional, the impulsive, and the purely instinctive part of our nature is laid bare.[2]

316. The Last Stage. In the last stage which may result even from drinking a single large amount of alcohol, the paralysis of the nerve centers and of the brain is carried to a greater extent. All the inlets of the senses are closed,

[1] Men following intellectual pursuits are apt to be victims of mental and bodily degradation through alcohol, for once they come under its subtle control, the craving for it in men of educated brains is perhaps stronger than in men of uneducated brains. — T. S. Clouston, M.D.

Alcohol destroys the individuality of man and paralyzes his body and his will power. — A. Baer, M.D.

[2] The stimulating action which alcohol appears to exert on the functions of the brain is only a paralytic action. The cerebral functions which are first interfered with are the power of clear judgment and reason. The lively gesticulations and useless exertions of intoxicated people are due to a kind of paralysis, — the restraining influences being removed which prevent a sober man from uselessly expending his strength. — G. von Bunge, Professor of Physiological Chemistry, University of Basel.

all consciousness and sensation are lost, and all power over the voluntary movements is gone. The heart still beats, the blood circulates, and the breathing still goes on; but these are the sole remnants of vitality, — the slender threads by which a hold is retained upon life.

317. Progressive Changes in Character caused by Strong Drink. The person who habitually, or even occasionally, stupefies his faculties or paralyzes his judgment and reason with alcoholic drinks disqualifies himself by this action for responsible duties. In family and social relations he is often irritable, unjust in his judgments, careless sometimes

FIG. 147. The Main Nerve Trunks of the Right Forearm, showing the Accompanying Radial and Ulnar Arteries. (Anterior view.)

to the extent of absolute cruelty in his responsibilities to those related to him by the tenderest ties. In business he becomes incapable of continued application, loses the sense of responsibility, and may become actually dishonest.

Most railroads now demand total abstinence of their employees. From a strictly business point of view it does not pay great corporations to employ engineers, switchmen, telegraph operators, or men in any responsible position who use alcoholic liquors. The directors know too well that the risk of life, limb, and property is thereby greatly increased.

Other industries are rapidly adopting the same measures as a protection against loss and accidents. Insurance

companies class even moderate but habitual users of alcoholic liquors as "extra risks." The great mass of statistics gathered by these companies, bearing upon the tenure of human life, go to show that the man who never drinks alcoholic beverages is likely to live longer than one who does.

318. The Final Result of Alcoholism. After a longer or a shorter time the usual result of the continuous use of alcoholic liquor is steadily to weaken the self-control of its victim, and at last to make him a slave to his lower nature. The craving for ardent spirit becomes well-nigh irresistible. Self-respect, honor, conscience, everything, is sacrificed in this craving for strong drink.

The disease known as *delirium tremens*, meaning a trembling madness, is not an uncommon instance of the profound effect of the habitual use of alcohol upon the nerve centers.

There is still another depth of ruin in such a downward course, and that is insanity. In fact, every instance of complete intoxication is a case of temporary insanity, — that is, of mental unsoundness with loss of self-control. Permanent insanity may be one of the last results of intemperance. Alcoholism sends to our insane asylums a large proportion of their inmates, as ample records testify.[1]

319. Moral Effect of the Alcoholic Habit. The once active will power of the man who has become the victim of alcohol is a thing of the past. He can no longer resist the feeblest impulse to temptation. The grand faculty of

[1] About thirty per cent of the male cases in lunatic asylums where inebriates are taken may be classed as direct alcoholic lunacy. The indirect victims of the drunken habits of their ancestors no doubt form a larger, but incalculable, number of the inmates of such asylums. — A. Forel, M.D.

self-control is lost, and as a result the baser instincts of his lower nature are now uppermost; greed and appetite often rule unrestrained.

The moral power of such a man is also dragged down to the lowest depths. The finer sensibilities of character are deadened; pride of personal appearance, nice self-respect and proper regard for the good opinion of others, the sense of decorum, are gone, and at last even decency disappears. Dignity of behavior may yield to silliness, and the person lately respected becomes an object of pity and loathing.

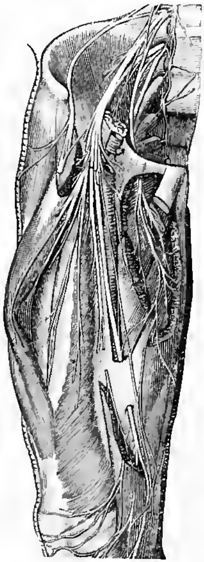

FIG. 148. A Great Nerve (Crural) and its Branches on the Front of the Thigh.

The femoral artery with its cut end is shown.

Convictions of right and wrong now find little place in his nature; conscience is silenced, dishonesty prevails. This is true both as to solemn promises, and also as to property. The drunkard may resort to any form of fraud or theft to feed the consuming craving for more alcohol.

320. Hereditary Results of Strong Drink. We may inherit mental and physical vigor or weakness, our features, and even moral tendencies. The children of parents whose brains are injured by alcohol are more prone than others to mental disorders and to those widely varied diseases which, for lack of a better name, we vaguely call "nervous." This is proved by the unusual prevalence in

such families of infant mortality, convulsions, epilepsy, hysteria, obscure brain diseases, and imbecility.[1]

321. Tobacco and its Effect upon the Nerve Centers. Tobacco, whether snuffed, chewed, or smoked, is a narcotic and a poison. Its injurious effects are due to its active principle called *nicotine*, which is a narcotic poison.[2]

Tobacco is hurtful to young people, and by no means free of harm to adults. It produces an artificial exhaustion, as it were, of the nerve centers. The tobacco habit once acquired generally leads to continual and increasing use.

Thus, after a time, tobacco may produce functional derangement of the nervous system, palpitation of the heart, certain forms of dyspepsia, and more or less irritation of the throat and lungs.[3]

Sometimes, after long smoking, a sensation of dizziness, with a momentary loss of consciousness, is experienced. While the stomach is empty, protracted smoking will often produce a feeling of nausea, accompanied by a headache.

[1] Of all the effects of alcohol, none are so deplorable as the fact that the offspring must suffer for the craving of its parents. This is more apparent when both father and mother have been habitual alcoholics. — P. M. Lightfoot, M.D.

A man may claim that he has drunk whisky all his life and is yet in a good state of preservation. Such may be the case, but to see the full effect of his habit, look at his children, and we find that they will not compare favorably with those whose parents have not been given to strong drink. — *Journal of the American Medical Association.*

[2] The external application of tobacco to chafed surfaces, and even to the healthy skin, will occasion severe and sometimes fatal results. A tea made of tobacco, and applied to the skin, has caused death in three hours. Smoking a large quantity of tobacco at one time has been known to produce violent and even fatal effects. Nicotine is one of the most rapidly fatal poisons known. It takes about one minute for a single drop to kill a full-grown cat. One drop has killed a rabbit in three minutes.

[3] I never smoke because I have seen the most efficient proofs of the injurious effects of tobacco on the nervous system. — Charles Édouard Brown-Séquard, M.D.

322. Effect of Tobacco upon the Nervous System. The cells of the brain may become poisoned from tobacco. The ideas may lack clearness of outline. The will power may be weakened, and it may be an effort to do the routine duties of life. The old tobacco user is often cross, irritable, and liable to outbursts of passion. The memory may also be impaired.

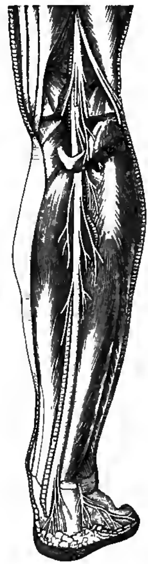

FIG. 149. A Great Nerve (Posterior Tibial) on the Back of the Leg, with its Accompanying Artery of the Same Name.

The narcotic principle, the deadly nicotine, has retarded the nutrition of the delicate nerve cells. The nerve centers are no longer able to hoard up their usual amount of vital energy. Hence arise the many and various nervous symptoms due to the poisonous effect of tobacco. Many men in mature life, especially those engaged in sedentary occupations, suffer from nervous breakdown in consequence of the habitual use of this noxious weed.

323. Smoking Cigarettes. The smoking of cigarettes cannot be too severely condemned. They are often made of the cheapest materials, and sometimes "doctored" with refuse substances, and even forms of opium, in order to give some bulk and "tone" to the originally cheap material. Cigarettes are so common and so cheap that their use by thousands of young persons has become a serious matter. The laws of many states very properly forbid the sale of tobacco, especially of cigarettes, to minors.

324. Effects of Tobacco upon Young People. Tobacco, in any form, has a peculiarly injurious effect upon young and growing persons.[1] It not only stunts their growth, but produces a weakened state of the system, which tends greatly to impair muscular and mental activity. The profound effect that tobacco has upon the nervous system after the first trial of smoking or chewing is matter of familiar experience.

Even after the system gets used to the narcotic, young people continue to suffer oftentimes from nausea, dizziness, headache, muscular trembling, loss of appetite, and general weakness.

Here is one bit of advice for you to remember all the days of your life: Do not smoke or chew tobacco if you wish to keep strong and well, and to succeed in life.

325. The Use of Tobacco from a Moral Point of View. The effect of tobacco on the moral nature often shows itself in a selfish disregard for the rights of others. The smoker has no right to make with his tobacco smoke the air about him unfit for others to breathe. He has no right to puff his smoke into the faces of people on the streets, or thus to pollute the air of public places which others are obliged to share with him.

The fact that he does this knowing that to many people the smoke of tobacco is offensive, and that some are even

[1] While tobacco is injurious to every one, it is far more harmful to those who are growing. A boy who uses tobacco can never have the strength of body or the vigor of mind he would have had except for its use. Boys and young men entering the employ of a great business house or a corporation where their success depends upon strength, alertness, skill, and accuracy, as well as integrity and industry, would surely reach a much higher success if they abstained totally from all narcotics. — WINFIELD S. HALL, M.D., Northwestern University Medical School, Chicago.

made sick by it, shows his lack of refinement as well as moral sense. Other evidence of the same character is the filthy habit of spitting on sidewalks, floors, stoves, and other objects, with which some smokers and chewers of tobacco disgust all cleanly people.

326. Harmful Effect of Tobacco upon the Mental Development of Young Students. Our military and naval academies and many seminaries and colleges very properly prohibit the use of tobacco by their students. The honors of the great schools, academies, and colleges are very largely taken by the abstainers from tobacco. This is proved by the result of repeated and extensive comparisons of the advanced classes in a great number of secondary schools and colleges both in this country and in Europe.

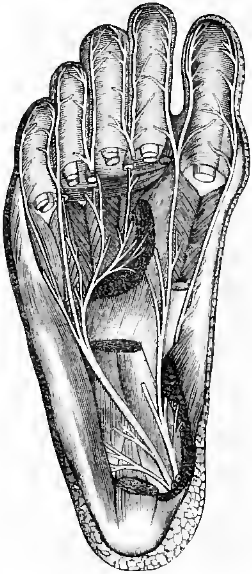

FIG. 150. A Great Nerve (Plantar) and its Branches which supply the Bottom of the Feet.

Note the cut tendons of the great muscles of the leg.

The reason for this is plain. The mind of the habitual user of tobacco is apt to lose its capacity for study or successful effort. This is especially true of boys and young men. The growth and development of the brain having been once retarded, the youthful user of tobacco has established a permanent drawback which may hamper him all his life. The keenness of his mental perception may be dulled and his ability to seize and hold an abstract thought may be impaired.

327. Opium and its Various Forms. Opium, one of the most powerful of the narcotic poisons, is the dried juice of the white poppy. It has the power of deadening the nerves and producing a kind of deep sleep or stupor.

Morphine, a white powder, is a very condensed form of opium. **Laudanum** is an alcoholic solution of opium. **Paregoric** is a diluted and flavored form of an alcoholic tincture of opium.

The various forms of **opium** are very generally used in patent medicines. They form the "soothing" basis of liniments, cough killers, soothing sirups, stomach bitters, cholera mixtures, and numerous other preparations which some persons are eager to buy, hoping to get relief from some real or fancied disease.

328. The Ruin wrought by Opium upon its Victim. The habit of taking opium completely changes its victim. A once upright and honest man will lie, cheat, and defraud, to satisfy his craving for this baneful drug. Promises and resolutions to stop its use may be honestly made, but are no more binding than ropes of sand.

329. What may lead to the Opium Habit. Some persons, jaded with business or with worry, and unable to sleep, unwisely resort to some narcotic mixture to procure rest. Occasionally persons getting better from some serious sickness in which opiates were taken find that the desire for these drugs clings to them long after recovery. In these and other similar cases, the use of opiates is always most dangerous.

330. The Opium Habit. Opium is a most dangerous drug because its use is so liable to lead to the **opium habit.** This is a craving for opium that makes life a burden for its victim. The person may have begun its use in the most

innocent way to relieve pain or to secure rest. But before he realizes his peril, he finds that it is all but impossible to leave off its use.

331. Caution in the Household Use of Opium. Never rub any form of opium upon an abraded surface to relieve pain. It may be rapidly taken up by the blood. Rubbing the gums of teething children with paregoric, putting laudanum into a child's aching tooth or ear, giving either preparation for "summer complaints," and many other ways of using opium, are dangerous practices. Laudanum that has been kept in the house for a long time may become much stronger than at first, on account of the evaporation of the alcohol.

The so-called soothing sirups and cough or cholera mixtures often given to infants and young children all contain more or less of some form of opium. The child is simply drugged, and not cured, however "soothing" the effect may be. The only safe rule is, never to put opium on the list of home remedies.

332. Chloral. Chloral is a powerful drug, capable, in small doses, of producing sleep. This action is probably due to its direct effect upon the brain. In full doses it depresses the action of the nerve centers of the brain and spinal cord.

Because **chloral** is known to induce sleep, especially in those who suffer from excessive mental strain, or from anxiety, or other like cause, it has come, of late years, to be used often without a physician's advice.

333. The Chloral Habit. Like all narcotics, the chloral dose must be steadily increased to get the required effect. The **chloral habit** is soon formed, and the person becomes a slave to a dangerous drug. Without it, the chloral eater

cannot sleep; with it, his digestion is sadly out of order. He suffers from dyspepsia, shortness of breath, and palpitation of the heart. The only safe rule is, never to touch so powerful, uncertain, and dangerous a drug.

334. Other Powerful Drugs and Narcotics. Chloroform, ether, cocaine, and other narcotics should never be used, even in the smallest doses, except under medical advice. They are dangerous agents at all times, and are used with great caution, even by physicians. Persons who get into the habit of tampering with such powerful drugs run the ever-present risk of killing themselves by an overdose.

335. Some Other Dangerous Drugs. Since the far-reaching epidemic known as influenza, or **la grippe**, or "grip," has made such sad havoc in recent years with the lives and health of the people, a new class of powerful drugs has come into popular use. These remedies are too dangerous and uncertain for household use.

The drugs sold as "headache" remedies should be let severely alone. If a person has a headache, it is better to find the cause, so that it may be avoided in future, than to continue the wrong living that brings on the headache and then try to relieve it by the use of harmful drugs.

Kola and coca are drugs now widely advertised as harmless and as nerve restorers. This is not true. Any feeling of restoration which these drugs may at first produce is a delusion that must be paid for afterward by feelings of lassitude and weakness. Nature alone holds the magic cordials which really have power to restore lost strength or vigor. Her prescriptions are rest, food, pure air, sunlight, and a cheerful mind.

QUESTIONS ON THE TEXT

1. What have we learned in preceding chapters to show that all parts of the body work together in harmony? 2. How may the nervous system be compared to a telegraph system? 3. Of what is nerve tissue made up? 4. Describe nerve cells. 5. Describe the structure of nerve fibers. 6. What simple experiment illustrates the structure of a nerve? 7. What is the general arrangement of the nervous system? 8. Of what does the brain consist? 9. What are the most important functions of the brain? 10. What can you say about the weight of the brain?

11. What are the three principal parts of the brain? 12. Describe the cerebrum. 13. Describe the cerebellum. 14. What is the medulla oblongata? 15. What are cranial nerves? 16. Describe the spinal cord. 17. What is reflex action? 18. Give some familiar illustrations of reflex action. 19. How does reflex action give relief to the brain? 20. Describe the spinal nerves.

21. What is the sympathetic nervous system? 22. State briefly how the sympathetic system acts. 23. By what apparently slight causes may the health of the nervous system be disturbed? 24. How may the brain power be increased? 25. What is the effect of worry on the nervous system? 26. What can be said about the importance of sleep? 27. Give some practical points about sleep. 28. What are some of the first effects of alcoholic liquors upon the nervous system? 29. Show how the power of self-control is weakened by strong drink. 30. What are some of the progressive changes in character caused by alcoholic liquors?

31. What are some of the final results of alcoholism? 32. What is the moral effect of the alcohol habit? 33. What may be the hereditary results of strong drink? 34. State in a general way the effect of tobacco upon the nervous system. 35. What is the effect of tobacco upon the physical health of young people? 36. How may tobacco retard the mental development of young students? 37. What is opium, and what are some of its various forms? 38. What is meant by the opium habit? 39. What is chloral and what is the chloral habit? 40. Mention some other dangerous drugs and give some precautions about their use.

CHAPTER XI

THE SPECIAL SENSES

336. Sensation. Everybody knows that the tongue is sensitive to taste, the nose to smell, the ear to sound, and the eye to light. In other words, each one of our sense organs has its own peculiar structure and is sensitive to some special agency called a **stimulus.** These stimuli give rise to nerve impulses or **sensations** which are transmitted by nerve fibers to the central nervous system.

Exactly how feeling, or **sensation,** leaves its imprint on the cells of the brain and rises to consciousness is not known.

337. General Sensations. Some sensations, or feelings, are of a very general character. Thus, we have a feeling of hunger or thirst, indicating a need of food or drink. To these may be added the sensations of pain, tickling, and itching. Other **general sensations,** such as those of fatigue, restlessness, and faintness, spring up within us in some mysterious way, sometimes without any obvious cause.

338. Sensations resulting from an Outward Agency. The great majority of sensations, however, result from some outward stimulus or agency. Thus, if we hear a child cry or a bird sing, we have a sensation of sound. If we put a piece of sugar on the tongue, hold a rose to the nostrils, or prick the skin with a needle, certain sense organs receive the impressions. The sensory nerves carry these impressions to the brain, and we become conscious of a sensation.

339. The Special Senses. There are certain avenues by which we get information concerning the world around us. In other words, we are provided with a number of **special senses** by means of which information is furnished us regarding outward forces and objects.

These special sense organs, or "gateways of knowledge," are the **skin**, the chief organ of touch and temperature; the **tongue**, the chief organ of taste; the **nose**, of smell; the **ear**, of hearing; and the **eye**, of sight.

340. Touch. The sense of **touch** is the most widely extended of all the senses, and perhaps the simplest. It has its seat in the skin all over the body and in the lining of the mouth and nasal passages. By this sense of touch we can tell whether a body is hard or soft, hot or cold, rough or smooth.

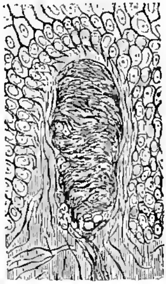

FIG. 151. A Papilla of the Skin, with a Touch Corpuscle. Highly magnified.

We have learned about the thousands of tiny hillocks called **papillæ**, which form rows of very thick ridges on the tips of the fingers (Sec. 254).

Now, besides a tiny artery and vein, finer than the finest hair, there is in each papilla the end of a sensory nerve. Where the sense of touch is most delicate, the papilla is found to contain a little oval bulb called the **touch corpuscle**.

NOTE. — There is another sense, commonly known as the **muscular sense**, which enables us to judge the weight of different bodies according to the muscular effort required to lift or hold them. This sense becomes so highly developed by use that shopkeepers and others who sell various articles by weight can often tell the weight of a body by simply balancing it in their hands.

The sense of **heat** and **cold**, or sensation of **temperature**, may also be regarded as a distinct sense.

All parts of the body have not this sense of touch in an equal degree. The sense of touch is most delicate in the tip of the tongue, the tips of the fingers, and the edges of the lips, and least delicate in the middle of the back.[1]

341. Sensations of Heat and Cold. The skin also judges to a certain extent of **heat** and **cold**. These sensations can be felt only by the skin and the lining membrane at the entrance to various passages.

The sensitiveness of the skin to heat and cold varies in different parts of the body. The palms of the hands and the bends of the joints are sensitive parts. A woman holds her iron near her cheek to tell whether or not it is hot. Nurses test the heat of the baby's bath by plunging the elbow into the water.

Experiment 68. *To illustrate the muscular sense.* Take two equal iron or lead weights; heat one and leave the other cold. The cold weight will feel the heavier.

Experiment 69. *To test the sense of locality.* Ask a person to shut his eyes; touch some part of his body lightly with the point of a pin, then remove it, and ask him to indicate the spot touched.

Experiment 70. Our sensations of heat and cold depend on the temperature of the skin. Place one hand in cold and the other in hot water, then plunge both in lukewarm water. To the cold hand the lukewarm water will appear hot, while to the warm hand it will seem cold.

[1] The sense of touch may be said to belong to every animated being, and is one great characteristic of animal life. In many animals the tongue is an instrument of touch as well as of taste. Certain animals, in addition to the tongue, have special organs of touch, such as the whiskers of the cat and the rabbit. These are really parts of the skin.

There is no other sense so capable of improvement as that of touch. The blind learn to read with ease by passing their fingers over raised letters. A famous botanist was blind, but was able to distinguish rare plants by the fingers and by the tip of the tongue. The silk weavers of Bengal are said to be able to distinguish, by the touch alone, twenty different degrees of fineness in the unwound cocoons.

342. Taste. The sense of **taste** is located chiefly in the tongue. Its surface is covered with countless numbers of tiny hillocks, or **papillæ**, which are abundantly supplied with delicate nerve fibers from two great nerve branches leading from the brain.[1] These are the nerves of taste. In many of the papillæ are peculiar structures called **taste buds**, or **taste goblets**, which are believed to be connected with nerve fibers. Similar taste buds are scattered over the surfaces of the soft palate and the epiglottis.

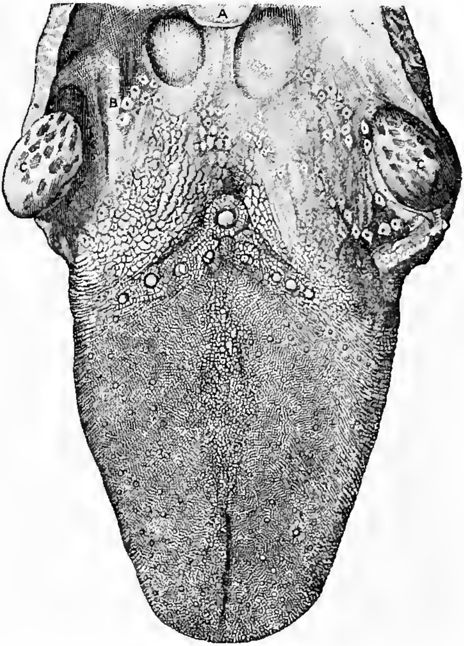

FIG. 152. The Tongue.

A, epiglottis; *B*, glands at the base of tongue; *C*, tonsil. The various kinds of papillæ are plainly shown.

It makes a difference in the taste whether we put a substance to be tasted on the tip or the back of the tongue.

Thus, sugar or any other sweet substance is tasted best at the tip, while a bitter substance, like quinine, tastes more bitter at the back of the tongue.

[1] In certain animals the papillæ are very largely developed and give a roughness to the tongue. It is this which enables the lion or the tiger to strip off the flesh from a bone by simply licking it.

The sensations of the tongue are very complex. They are really combinations of the sensations of touch and taste. Strictly speaking, we can tell by the sense of taste only whether anything is bitter, sweet, sour, or salt. We detect the *flavor* of food and drink by the sense of smell.

Experiment 71. Wipe the tongue dry and lay on its tip a few grains of granulated sugar. It is not tasted until it is dissolved. Apply a few grains of sugar to the tip, and a few more to the back, of the tongue. The sweet taste is more pronounced at the tip.

Experiment 72. Prepare a solution of sulphate of quinine by dissolving a small quinine pill in a tablespoonful of hot water. It is scarcely tasted at the tip, but is tasted immediately on the back part of the tongue.

343. Smell. The sense of **smell** is located in the membrane which lines the cavities of the nose. This delicate membrane, over which the fibers of the **olfactory nerves**, or the nerves of smell, are distributed, is kept continually moist by the mucus which it secretes. At the beginning of a cold in the head it becomes dry and swollen, and the sense of smell may be greatly lessened.

FIG. 153. Nasal Cavities, seen from Below.

It is in the upper parts of the nasal cavities that the sense of smell is most acute.[1] Hence, when we wish to detect a faint odor we sniff

[1] The sense of smell varies very much in different individuals. Among civilized people it is often defective, while in savage races it is notably acute. We are told that the South American Indians can detect the approach of a stranger, even on a dark night, by their sense of smell, and can also tell whether he is white or black. Many animals are more highly endowed with this sense than man. Thus, a dog will smell the footsteps

the air sharply. The sense of smell seems to be nature's sentinel to guard us against taking improper food into the stomach and impure air into the lungs.

Experiment 73. *To show that we often fail to distinguish between the sense of taste and that of smell.* If we chew some pure roasted coffee, it seems to have a distinct taste. Pinch the nose hard while chewing it, and there is little taste. Coffee has a powerful odor but only a feeble taste. The same is true of garlic, onions, and various spices.

Experiment 74. Light helps the sense of taste. Shut the eyes, and palatable foods taste insipid. Pinch the nose, close the eyes, and see how palatable one half of a teaspoonful of cod-liver oil becomes.

Experiment 75. Close the nostrils, shut the eyes, and attempt to distinguish by taste alone between a slice of an apple and one of a potato.

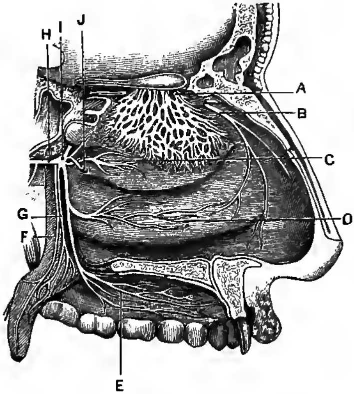

FIG. 154. Distribution of Nerves over the Interior of the Nostrils. (Outer wall.)

A, branches of the nerves of smell; *B*, nerves of touch to the nostrils; *E*, *F*, *G*, nerves to the palate springing from a ganglion at *C*; *H*, a branch of the facial nerve, from which other branches, *D*, *I*, and *J*, spring to be distributed to the nostrils.

344. The Sense of Hearing. We come now to a special sense, which does not tell us what is going on in the outer world by actual contact, as in touch or taste, nor by particles of matter falling upon the ends of nerves, as in the sense

of his master amid those of a hundred other people, and can track him for miles, although he has been for hours out of sight. Hounds track the fox or the deer by the sense of smell. Dogfish find their prey by the sense of smell rather than by sight.

of smell. In the sense of **hearing**, impressions are made upon the nerves by wavelike vibrations in the surrounding air.

All sounds are caused by the vibration of something in the atmosphere. The object struck sends out these vibrations to the surrounding air, which carries forward a series of waves in all directions.[1]

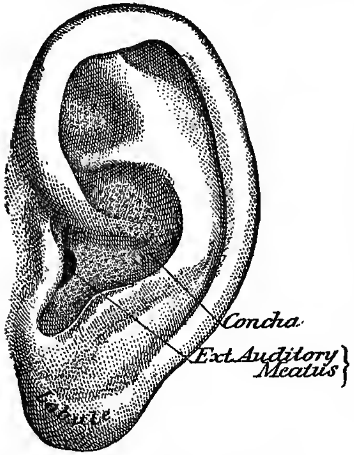

FIG. 155. The Pinna, or Auricle.

345. The Organ of Hearing. The air waves are received, and the impression made by them is sent to the brain, by a special apparatus, called the organ of hearing. It is lodged in the temporal bone, one of the thick, inner bones which form the base of the skull.

The **ear**, the organ of hearing, is far more complicated than any of the organs of sense yet described. It is second only in importance to the eye, the organ of sight.

The ear is divided into three parts, — the **outer**, the **middle**, and the **inner** ear.

346. The Outer Ear. The **outer ear** consists of a plate of gristle, shaped somewhat like a shell, known as the **pinna**,

[1] We shall understand these air waves better if we throw a stone into a pool of water and watch the result. We see a series of tiny circular ripples gradually spread themselves over the surface of the water from the spot where the stone fell. This exactly represents the waves of sound caused by the vibration of bodies in the air. These air waves travel with wonderful rapidity. The usual velocity of sound is about eleven hundred feet a second.

or **auricle**, and of a tube about an inch long, called the **auditory canal.**

The **auricle** is used as a kind of ear trumpet to gather up the sound waves. Many animals are able to move the large external ear in the direction of the sound. Thus, the horse and the rabbit prick up their ears when they hear a noise, the better to judge of the direction of sounds.

The **auditory canal** is a passage in the solid portion of the temporal bone. It is lined by skin on which there are fine hairs, and a set of glands secreting earwax, which serves to moisten the parts, catch particles of dust, and keep away small insects.

The inner end of the auditory canal is closed by a membrane stretched tightly across it. It resembles the parchment stretched across the end of a drum, and is known as the **tympanic membrane**, or **drum membrane.** It is thin and elastic, but may be broken by a blow, or by pushing some sharp or hard substance into the ear.

347. The Middle Ear. The **middle ear** is a small, drumlike cavity, full of air, in the temporal bone. This cavity is known as the drum of the ear, or **tympanum.** On the inner wall of this air chamber are two small openings, the "oval window" and the "round window," both of which are closed by membranes. The most curious feature of the middle ear is a string of three tiny bones which stretch across it. These bones are called from their shape the **hammer,** or *malleus;* the **anvil,** or *incus;* and the **stirrup,** or *stapes.*

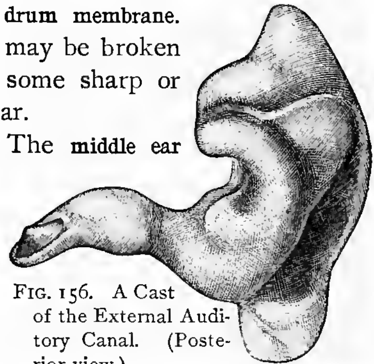

Fig. 156. A Cast of the External Auditory Canal. (Posterior view.)

The hammer bone is fastened by its long handle to the drum membrane. The round head of the hammer bone fits into the anvil bone. Next to the anvil is the stirrup bone, which fits into the little oval window in the opposite wall of the chamber or drum.

348. The Eustachian Tube. In the floor of the tympanic cavity is the opening of a passage called the **Eustachian tube.** This tube is about an inch and a half long, and leads into the back part of the throat. It allows air from the throat to enter the drum, and serves to keep the air on both sides of it at equal pressure (Fig. 69).

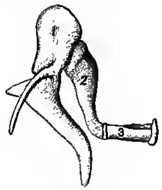

FIG. 157. The Bones of the Ear.

1, malleus, or hammer; 2, incus, or anvil; 3, stapes, or stirrup.

During a severe cold in the head, or a sore throat, the lining of the tube may be inflamed and swollen. This gives a stuffed feeling in the ears, and the hearing may be slightly impaired. As the cold passes off, this peculiar feeling in the ears usually disappears.

Experiment 76. *To produce vibration of the tympanic membrane and the little ear bones.* Shut the mouth and pinch the nose tightly. Try to force air through the nose. The air dilates the Eustachian tube and is forced into the ear drum. The distinct crackle, or clicking sound, is due to the movement of the ear bones and the tympanic membrane.

349. The Inner Ear. The **inner ear** is a bony case filled with liquid in which float the delicate ends of the nerve of hearing. It consists of three distinct portions, — the **vestibule**, the **semicircular canals**, and the **cochlea**, or *snail's shell.* It is enough for us to remember that these are winding channels and spiral tubes hollowed out in the solid bone. The whole system of passages is known as the *labyrinth.*

It is important to remember that there is a continuous connection between all the passages of the inner ear, and that all the winding tubes and chambers inclose and protect a delicate bag of membrane of exactly the same shape as themselves.

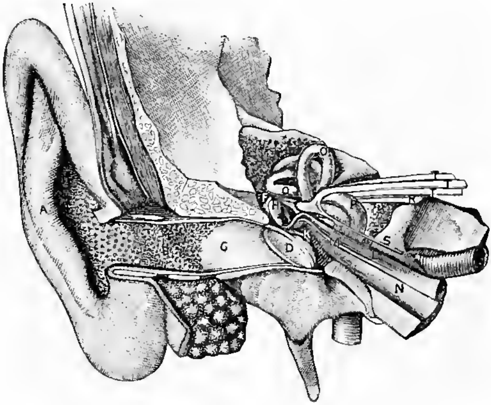

FIG. 158. General View of the Organ of Hearing.

A, pinna; *B*, cavity of the concha, showing the openings of a great number of sebaceous glands; *C*, external auditory meatus; *D*, tympanic membrane; *F*, incus; *H*, malleus; *K*, handle of malleus applied to the internal surface of the membrana tympani; *L*, tensor tympani muscle; between *M* and *K* is the tympanic cavity; *N*, Eustachian tube; *O*, *P*, semicircular canals; *R*, internal auditory canal; *S*, large nerve given off from the facial nerve; *T*, facial and auditory nerves.

350. The Auditory Nerve. The **auditory nerve**, or nerve of hearing, passes to the brain, through a little hole in the solid bone of the skull, from the inner ear, where its nerve fibers branch round the sense cells on the inner walls of the lining membrane.

351. How we Hear. Let us learn a few of the simplest principles about this wonderful mechanism of the ear. A bell is rung or a gun fired. The vibration is communicated to the atmosphere around it, and passes away in air waves from the sounding body, as the waves ripple the surface of a pond after a stone has been thrown in.

The air waves pass into the outer ear and strike upon the stretched membrane of the drum, causing it to vibrate.

At every vibration of the membrane the head of the hammer bone strikes upon the anvil bone, drives it forward, and pushes the foot plate of the stirrup bone in and out of the oval window on the inner wall of the chamber.

The waves thus formed in the watery fluid in the inner ear strike against the membranous bag, and so arouse a nervous impulse in the fibers of the auditory nerve. The nerve of hearing transmits the auditory impulses from the sense cells to the seat of sensation in the brain, where they are interpreted as sounds.

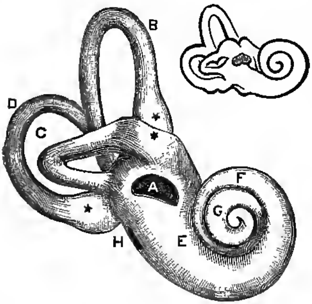

FIG. 159. Bony Internal Ear of the Right Side.

Magnified; the upper figure of the natural size.

A, oval window; *B*, *C*, *D*, semicircular canals; * represents the bulging part of each canal; *E*, *F*, *G*, cochlea; *H*, round window.

352. Hints on the Care of the Ear. The ear canal should never be rudely or hastily washed out. The utmost gentleness in washing out the ear is all that is necessary for cleanliness. The ears should never be pulled or boxed. Even a slight blow has resulted in serious trouble.

Never use earpicks, ear spoons, the ends of pencils or penholders, pins, hairpins, toothpicks, towel corners, etc., to pick, scratch, or cleanse the ear canal. It is a foolish, needless, and dangerous practice.

Let the earwax take care of itself. The skin of the ear grows outward, and the extra wax and dust will be naturally carried out if let alone. Never drop sweet oil, glycerin, or other fluids into the ear with the idea that it is made cleaner by them. They often cause irritation.

Cotton wads may be put into the ears to shield them from a cold wind, or may be worn while one is swimming or diving, to keep the water out. Diving into deep water or bathing in the breakers may injure the ears if not thus protected.

353. Additional Suggestions on the Care of the Ears. We should never shout suddenly in a person's ear. The ear is not prepared for the shock, and permanent injury has occasionally resulted. If the Eustachian tube is closed for the time, a sudden explosion, the noise of a gun or cannon, may burst the drumhead. Soldiers during heavy cannonading open the mouth to allow an equal tension of air on both sides of the membrane.

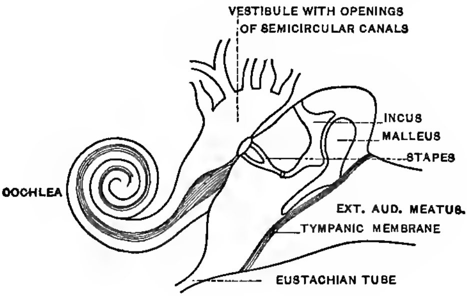

FIG. 160. BLACKBOARD SKETCH.

Diagram of the Middle and Internal Ear.

Flies, ants, and other insects sometimes crawl into the ear. This may cause some pain and fright, and perhaps lead to vomiting and even convulsions in the case of children. A lighted lamp put at the entrance of the ear will often coax insects to crawl out towards the light. The ear may be syringed out with a little warm water. Drop in a little sirup, melted vaseline, or sweet oil.

Cold water should never be used in the ears or nostrils if it can be helped. Use only tepid water. Do not go to sleep with the head in any position that may expose the ears to a draught of cold or damp air.

When one suffers from severe or continued earache it is always best to consult a physician. In the meantime some relief may be obtained by holding a hot sand bag or hot-water bottle to the ear.

354. Effect of Alcohol and Tobacco upon Hearing. Strong drink tends to inflame first the lining membrane of the throat and then that of the Eustachian tube. The inflammation may spread after a time to the delicate apparatus of the inner ear.

The immoderate use of tobacco may injure the sense of hearing. The irritating smoke, filling the deeper parts of the nose and throat, easily finds its way through the Eustachian tube and tends to irritate the delicate parts of the middle ear.

355. The Wonderful Sense of Sight. Sight is the highest and most perfect of all our senses. By means of it we may follow the vessel sailing along on the dim horizon, and the next instant we may be reading the fine print of a newspaper. By means of this sense we recognize the form, size, color, and distance of thousands of different objects in nature.

The sense of sight is so woven into the countless acts of our everyday affairs that we scarcely appreciate this marvelous gift, so essential, not only to the simplest matters of comfort, but also to the culture of the mind and the higher forms of pleasure.

356. The Eye. The **eye**, the outer instrument of sight, is a most beautiful piece of mechanism. This little organ, only about an inch in diameter, is in reality one of the greatest wonders in nature.

The eyeball is lodged in a bowl-shaped cavity made up of seven of the bones of the head and face. This eye socket is well protected on its edges by the dense and

strong bones of the head, and is padded with fat, which acts as a soft elastic cushion for the eyeball.

357. The Coats of the Eye. The walls of the **eyeball** are made up of three distinct coats, or coverings.

The **outer covering**, or *sclerotic*, is one of the toughest and strongest membranes in the body, and serves as a kind of

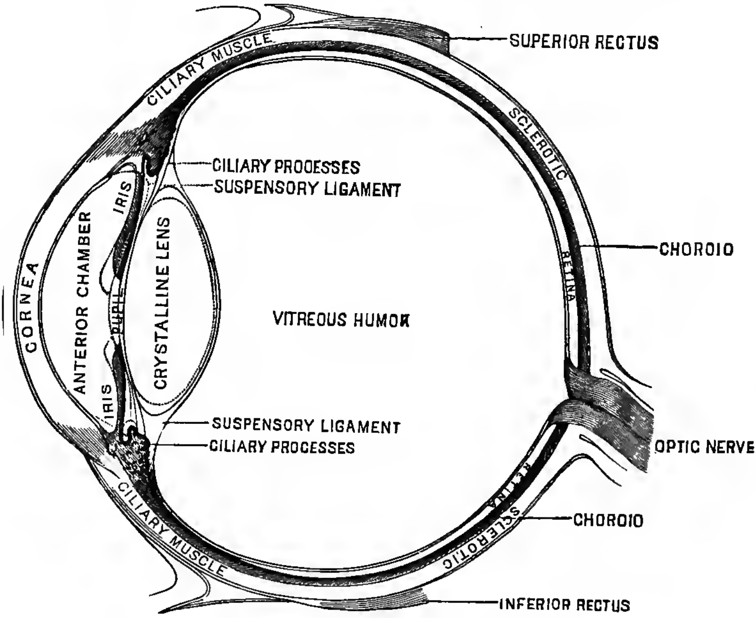

FIG. 161. BLACKBOARD SKETCH.

Section of the Human Eye.

elastic framework for the eye, and protects the delicate structures within. That part of it which is visible is known as the white of the eye.

This outer coat of the eyeball gives place in the front to a transparent circular plate, just as in a watch the gold or silver case gives place to a glass crystal over the face. This transparent plate, the **cornea**, forms a kind of rounded bay window for the eye, and is often spoken of as the window of the eye.

The **second coat**, or *choroid*, is much more delicate in structure and consists almost entirely of blood vessels and nerves. It is lined with a thick, black coating designed to absorb the surplus rays of light, which would otherwise cause blurred or confused vision. In many animals the choroid is rich with colors; hence the green sheen of a cat's eye.

358. The Retina. The **retina**, meaning a net, the innermost coat of the eyeball, is an extremely delicate and sensitive screen upon which the image is formed. It is a net of fibers proceeding from the optic nerve and spread out over the inner surface of the eye.

359. The Iris and Pupil. To get a clear idea of the inner parts of the eye, let us imagine an eyeball cut through the middle from above downwards. Let us now start in front and go backwards (Fig. 161).

We shall first see the **cornea**, which has just been described.

We now reach a space called the front chamber of the eye. In this chamber, and behind the cornea, is hung a round curtain, the **iris**, meaning rainbow. It is pierced by a hole through its center for the admission of light. This is called the **pupil**, which appears as if it were a black spot. It is this curtain which gives the color to the eye. The iris has muscular fibers which contract and relax, and thus make the pupil larger or smaller, according as the light is bright or dull.

When the light is very strong and brilliant the iris spreads its curtain farther over the pupil in order to shut out some of the rays. When the light is faint the curtain is drawn back, making the pupil larger in order to admit as many rays of light as possible.

The black appearance of the pupil is due to the thick black coating which lines the inside of the choroid and prevents all light from passing through the wall of the eyeball. It is like looking through a small window into a dark room.

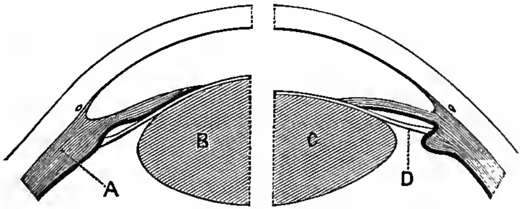

FIG. 162. Diagram showing the Change in the Lens during Accommodation.

On the right the lens is arranged for distant vision, the ciliary muscle is relaxed, and the ligament *D* is tense, so flattening by its compression the front of the lens *C*; on the left the muscle *A* is acting, and this relaxes the ligament and allows the lens *B* to become more convex, and so fitted for the vision of near objects.

360. The Crystalline Lens. Just behind the iris is a clear, transparent, jellylike body, called the **crystalline lens**. It is convex, or rounded, both back and front, and is about one third of an inch in diameter. It is shut up in a kind of transparent bag and is held in its place by a number of little bands. The crystalline lens separates the front chamber of the eye from the back chamber.

The front chamber is filled with a clear, watery fluid called the **aqueous**, or *watery*, humor. This fluid keeps the

cornea uniformly convex and allows the curtain with the hole in it — the iris — to float and move at freedom. The back chamber contains a jellylike fluid called the **vitreous**, or *glassy*, humor.

361. The Course of the Rays of Light in the Eye. Let us now master a few points about the mechanism of vision. Let us trace the course of the rays of light going from any luminous body — a lighted candle, for example — through the different parts of the eye. Imagine the candle to be placed about ten inches in front of the eye.

Some of the rays fall on the outer coat, or the white, of the eye, and, being turned back or reflected, take no part in vision. The more central rays fall upon the cornea. Some of these are reflected, giving to the surface of the eye its beautiful, glistening appearance.

Now, if the rays of light passed directly to the retina, they would pass in parallel lines and produce the impression of light, but everything would be dim and confused. Therefore it is necessary that the rays coming from any object should be brought together (converged) by being bent (refracted). That is, they must be refracted and brought to a focus.

362. The Work done by the Crystalline Lens. The rays of light are refracted and brought to a focus to a certain extent by the cornea and the fluids, or humors, of the eye, but mainly by the crystalline lens. It is thus the duty of the crystalline lens to bring the rays of light nearer together as they pass through it, and to bring them to a focus on the retina.

It is a familiar fact in the use of optical instruments that they must be differently adjusted for objects at different distances. The boy changes the focus of his spyglass by

pulling its tubes in or out. When we look from a distant to a near object with an opera glass, we change the focus by turning the adjusting screw.

A tiny muscle called the **ciliary**, or hairlike, muscle does for the eye what the adjusting screw does for the opera glass. As it contracts and relaxes, the elastic lens, held in place by a delicate membrane, becomes more rounded or flatter, according as we may wish to look at nearer or more distant objects.

In other words, our eyes adjust, or **accommodate**, themselves to the varying distances of objects, just as the photographer pushes in or out the lens of his camera so as to bring it nearer to or farther from the surface which receives the image (Fig. 162).

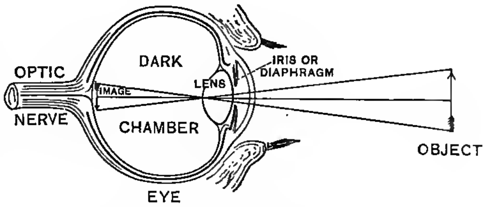

FIG. 163. BLACKBOARD SKETCH.

Diagram illustrating the Manner in which the Image of an Object is inverted on the Retina.

Experiment 77. *To illustrate accommodation.* Standing near a source of light, close one eye and hold up both forefingers not quite in a line, keeping one finger about six or seven inches from one eye, and the other forefinger about sixteen or eighteen inches from the other eye. Look at the *near* finger; a distinct image is obtained of it, while the far one is blurred or indistinct. Look at the far image; it becomes distinct, while the near one becomes blurred. Observe that in accommodating for the near object one is conscious of a distinct effort.

363. Formation of an Image on the Retina. The rays of light are thus brought to a focus on the sensitive retina. The iris has regulated with wonderful skill the proper

amount of light; and the lens, with the greatest exactness, has focused the rays on the retina. The dark surface of the middle coat acts to absorb the excess of light, the entrance of which would disturb accurate vision.

As a result, an exact but inverted image is formed on the retina. The impression is carried to the brain by the fibers of the optic nerve, which are spread out on this wonderfully sensitive membrane.

Experiment 78. *To show the blind spot.*[1] The retina is not sensitive where the optic nerve enters the eyeball. This is called the "blind spot." Put two ink bottles, about two feet apart, on a table covered with white paper. Close the left eye and fix the right steadily on the left-hand inkstand, gradually varying the distance from the eye to the ink bottle. At a certain distance the right-hand bottle will disappear, but nearer or farther than that it will be plainly seen.

364. The Muscles of the Eye. The eyeball is rolled and moved about by six muscles. They spring from the back part of the bony orbits and are fastened to the front part of the eyeball by means of tendons. Four of these muscles (the **recti**, or straight, muscles) move the eye up or down, and to the right or left. The other two (the **oblique**) are so fastened that they rotate the eyeball in one direction or another. If the eye muscles are not properly balanced in their action, squinting results.

[1] The location of the blind spot may be shown in the following simple manner. The left eye being shut, let the right eye be fixed on the cross below. When the book is held at arm's length both cross and round spot

will be visible; but if the book be brought to about eight inches from the eye, the gaze being kept steadily upon the cross, the round spot will at first disappear, but as the book is brought still nearer both cross and round spot will again be seen.

365. The Eyelids and Eyebrows. The eyes are protected and kept clean by their **eyelids, eyelashes,** and **eyebrows.**

The **eyelids** are thin, flexible covers, or shutters, which protect the front of the eyeballs. They are composed on the outside of skin, which is stiffened at the margin by thin plates of gristle. They are lined on the inner side with a very delicate mucous membrane called the *conjunctiva,*

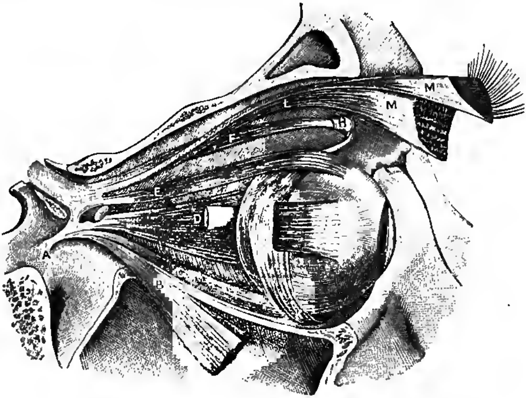

FIG. 164. Muscles of the Eyeball.

A, attachment of tendon connected with the four recti muscles; *B,* external rectus, divided and turned downward, to expose the internal rectus; *C,* inferior rectus; *D,* internal rectus; *E,* superior rectus; *F,* superior oblique; *H,* pulley and reflected portion of the superior oblique; *K,* inferior oblique; *L* and *M,* portions of the muscle which raises the upper eyelid; to the right of *D* and to left on same line are seen cut ends of the optic nerve.

because it is also joined to the eyeball by a fold. It pours out fluid to prevent friction between the surfaces. This fluid, together with the tears, which are constantly flowing, keeps the cornea moist and free from dust.

The edges of the eyelids are provided with a fringe of fine hairs, the **eyelashes,** which shade the eye and shield it from dust.

The **eyebrows** form a protecting and shading ridge over the eyes, while the thick fringe of hairs, arranged somewhat like the straw on a thatched roof, prevents the perspiration from rolling into the eyes as it trickles down the forehead.

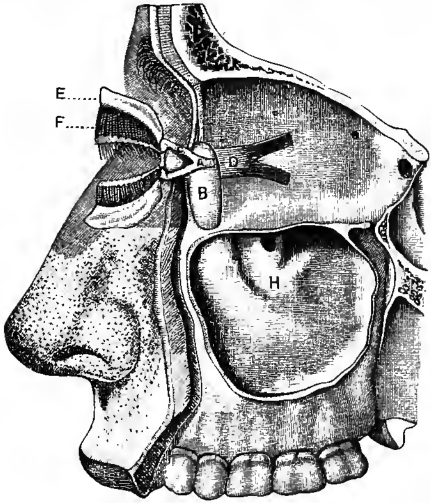

FIG. 165. The Relative Position of the Lachrymal Apparatus and the Eyelids.

A and *C*, lachrymal canals; *B*, lachrymal sac; *D*, small muscle which serves to compress the lachrymal sac; *E*, lining membrane of the upper and lower eyelids; *F*, glands upon the inner surface of the eyelids, with ducts opening upon the free margins of the eyelids; *H*, great opening, or antrum, of the upper jawbone. The oil glands of the nose are plainly shown.

366. The Tears. Nature provides a special fluid to protect the eye. This fluid is called the **tears**.

The tear apparatus consists of the gland for secreting a thin, watery fluid, the tears, and the passages for draining them off. The tears moisten the surface of the eye whenever the lids wink, and wash away the particles of dust.

The tears are carried off by two fine tubes, one in the upper and one in the lower lid, which unite and form a sac from which the **tear duct** leads into the nose. The ordinary flow of tears is thus drained off.

Emotion may excite an excessive flow which the canals cannot carry off. The tears then overflow and run down

the cheeks. This is called crying or weeping. The tears can be made to flow in a reflex way by almost any violent stimulation, as, for example, by irritation of the nasal passages by pepper.

367. Color Blindness. The inability to distinguish between certain colors is called **color blindness**. It is sometimes produced by sickness, but it may exist at birth and is often hereditary. It is incurable.

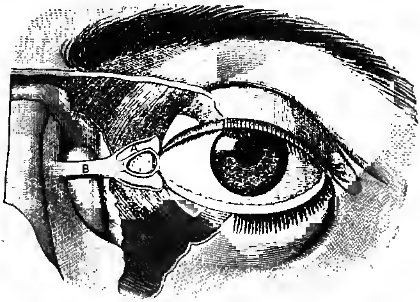

FIG. 166. The Relative Position of the Lachrymal Apparatus, the Eyeball, and the Eyelids.

A, lachrymal canals, with the minute orifices represented as two black dots to the right; *B*, tendon attached to a muscle which surrounds the circumference of the orbit and eyelids; under *B* is seen the lachrymal sac. The minute openings of the Meibomian glands are seen on the free margins of the eyelids. Below *A* is seen a small conical elevation, with black dots (the lachrymal papilla, or caruncle).

This defect of sight is quite common. Out of the many thousands that have been examined, it is found that four men out of every hundred are lacking in the power to distinguish between certain colors. Total color blindness is very rare.

A person who is color blind cannot match colors. He may pick up red, brown, and orange wools and match them with green of different shades. A person may be color blind and not know it until the defect is accidentally revealed.

This defect of vision is a matter of the utmost practical importance to those employed on electric and steam railways, vessels, and other places where colored signals

are used. The most common forms of color blindness are those in which one fails to distinguish red from green.

368. Near Sight. Near sight is a common defect of vision. In the healthy eye the rays of light are brought to a focus on the retina. But in some eyes the image is blurred; the outer coat bulges backward, making the eyeball a little too long, thus bringing the rays of light to a focus before they reach the retina. A person is said to be nearsighted because he can see near objects better than those at a distance.

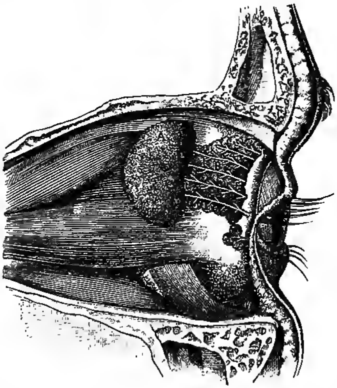

FIG. 167. Lachrymal Gland and Ducts.

A, lachrymal gland, the size of a small almond, lodged in the upper and outer part of the orbit; *B*, lachrymal ducts, which form a row of openings into the conjunctival fold.

Nearsightedness may exist at birth and is often hereditary. It is sometimes acquired by overstraining the eyes in reading too fine print, by reading by a dim or imperfect light, and in many other ways. This defect is common with those who use their eyes much in reading, writing, and study. Sailors, farmers, and others who work outdoors are rarely nearsighted.

There has been found to be a steady increase of nearsightedness, especially among school children. This defect of vision calls for skillful advice and careful treatment.

369. Long or Far Sight. A farsighted person is so called because he can see distant objects more easily than those near by. In a long-sighted person the eyeball is too

short and the retina lies too near the lens. In order to see near objects the little ciliary muscle must be put to a severe strain to make the lens convex enough. Thus it happens that the eye of a long-sighted person is usually under a strain when working. This leads to headache and fatigue. In childhood this strain may pass unnoticed for a time, but sooner or later it shows itself by a sense of fatigue, dizziness, and blurred and indistinct vision.

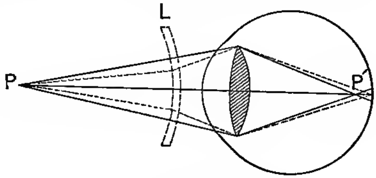

FIG. 168. Diagram illustrating the Nearsighted Eye.

The image *P′* of a distant point *P* falls in front of the retina even without accommodation. By means of a concave lens (*L*) the image may be made to fall on the retina (dotted lines). To save space *P* is placed much too near the eye.

370. How the Eyes may be abused in Reading. The habit of reading the daily papers, with their blurred and indistinct type, in a steam or electric car or in a carriage, is a severe strain on the eyes. The small type, poor paper, and presswork of the many cheap editions of popular books are very frequent causes of weak and diseased eyes. It is a dangerous practice to read in bed at night, or while lying on a sofa or lounge in a darkened room. The outer muscles of the eyeball are put to a great deal of strain.

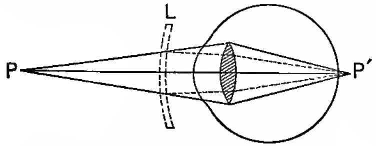

FIG. 169. Diagram illustrating the Farsighted Eye.

The image *P′* of a point *P* falls behind the retina in the unaccommodated eye. By means of a convex lens (*L*) it may be focused on the retina without accommodation (dotted lines). To save space *P* is placed much too near the eye.

371. Proper Light and Good Eyesight. The direction from which the light comes is an important matter. The worst

direction of all is that from the front. The direct light should fall upon the print from above and from the left side. The more nearly an artificial light resembles mellow daylight, the better. A flickering light is always bad. Artificial light should be regulated by shades and globes. Recently invented round and hollow burners used with kerosene oil give an excellent light.

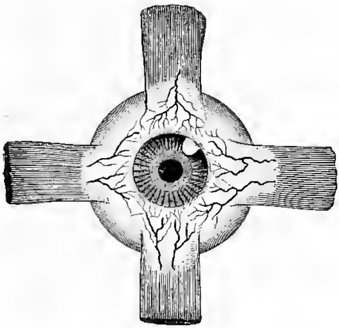

FIG. 170.

Showing the attachment of the recti, or straight muscles to the eyeball, also the distribution of arteries upon the outer coat of the eye.

Using the eyes at dusk, or by artificial light in the early morning, may lead to serious disorders of vision. The light reflected from snow is a common source of injury to the eyes. The eyes of infants should not be exposed to the glare of electric lights or to the direct rays of the sun.

372. Importance of Rest for the Eyes. After reading steadily for some time we should rest the eyes by looking at some distant object, even if only for a few moments. A person should never read, write, sew, or otherwise use the eyes when they tingle or smart, or when the sight is dim or blurred. The eyes are weary and need a rest.

The eyes are often weak after certain sicknesses. A long rest should be given them after an attack of measles or scarlet fever.

373. Additional Hints for taking care of the Eyes. The eyes should never be rubbed, particularly when they have been irritated by some foreign substance. The sooner it

is removed, the better. Rubbing the eyes or pulling the eyelids only makes a bad matter worse. When the eyes smart or tingle, after going to bed, and are bloodshot on getting up the next morning, it is safe to conclude that they have been irritated or overtaxed, and need rest. Riding against the wind, especially on a bicycle or in an automobile, is often hurtful, at least for eyes that are inclined to weakness or any form of inflammation.

It is not a wise economy to tamper with one's eyes when they are ailing. Better to do nothing than do the wrong thing. If a few days of rest do not give relief, a good oculist should be consulted at once.

FIG. 171. The Actual Size of the Test Type, which should be seen by the Normal Eye at a Distance of Twenty Feet.

374. Effect of Alcohol on Sight. The government coast survey every summer employs several small companies of men in measuring distances from high points along the coast. It has been found by experience that whenever these men indulge in strong drink their work is often impaired and faulty. They fail to signal correctly or to be accurate in their own records.

375. Effect of Tobacco on Sight. A personal examination, conducted by Dr. Francis Dowling, of about ten per cent of the employees of a Cincinnati factory employing fifteen hundred men showed many of the men who used tobacco, either chewing or smoking, to be suffering from a gradual failure of vision. With one exception, the women employees of the same factory who were examined by him gave no evidence of tobacco poisoning as manifested by troubles of vision.

QUESTIONS ON THE TEXT

1. What is meant by a stimulus? 2. What can be said about general sensations? Illustrate. 3. From what do most sensations result? Illustrate. 4. What are the special senses? 5. What are the special sense organs? 6. Describe the sense of touch. 7. What can you say about sensations of heat and cold? 8. Describe in full the sense of taste. 9. Where is the sense of smell located? 10. What general difference is there between the sense of hearing and that of touch, taste, or smell?

11. What is the organ of hearing, and what are its three general parts? 12. Describe the outer ear. 13. What is the tympanic membrane? 14. Describe the middle ear. 15. Give some details about the bones of the ear. 16. What is the Eustachian tube? 17. What is the inner ear? 18. Describe the three parts of the inner ear. 19. Describe the auditory nerve. 20. Explain in some detail how we hear.

21. Give some practical points about the care of the ears. 22. What is the general effect of alcohol and tobacco upon hearing? 23. What may be said in a general way about the sense of sight? 24. What is the eye, and where is the eyeball lodged? 25. Describe the coats of the eye. 26. What is the retina? 27. Describe the iris and the pupil. 28. What is the crystalline lens? 29. What are the two fluids, or humors, of the eye? 30. Describe the work done by the crystalline lens.

31. Describe in some detail the mechanism of vision. 32. How is the image formed on the retina? 33. Describe the muscles of the eye, and explain their action. 34. Describe the eyelids, and explain how they are kept moist. 35. What are the eyelashes and the eyebrows? 36. What are the tears, and of what does the tear apparatus consist? 37. What is color blindness? 38. What is meant by near sight? 39. Explain what is meant by long or far sight. 40. How may the eyes be abused?

41. What is the relation of proper light to good eyesight? 42. Why is rest of great importance to the eyes? 43. Give some practical hints about taking care of the eyes. 44. What is the general effect of alcohol on sight? 45. How may tobacco affect the sight?

CHAPTER XII

THE THROAT AND THE VOICE

376. The Throat. The **throat** is the common highway, as it were, through which food goes to the stomach and air to the lungs.

We have already learned something of the food passages (Chapter VI) and the air passages (Chapter VIII), and we are familiar with the hard palate, the soft palate, the uvula, and the tonsils (Figs. 63 and 69).

377. The Pharynx. The only way to get a proper idea of the throat is to look into a friend's mouth. First, let the person hold his mouth wide open, facing a good light. Hold the tongue down with the handle of a spoon (Fig. 63).

On looking directly into the back of the mouth we see the beginning of a passage called the **pharynx,** which is common to the two highways, or passages by which air and food are taken into the body. If we look at the top, we see the air passage which leads to the nose. The air tract at the top of the pharynx has two outlets, the mouth and the nose.

Now, if we pull the tongue firmly forward, a little curved ridge is sometimes seen behind it. This is the **epiglottis,** which, as we already know, is the trapdoor that shuts down, like the lid of a box, over the top of the air passage, or windpipe (Sec. 153).

The part of the throat directly opposite the line of vision, as we have learned, is the back wall of the pharynx, which continues downward to form the gullet, or food passage.

The pharynx runs up to the base of the skull behind, and ends in a kind of vaulted roof bent somewhat like a crooked forefinger.

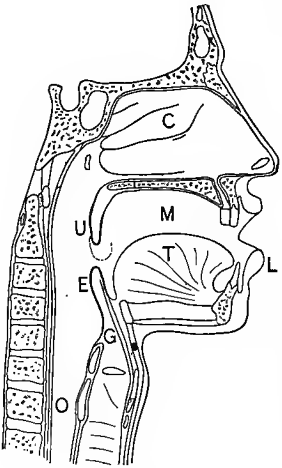

FIG. 172. BLACKBOARD SKETCH.

Diagram of a Sectional View of Nasal and Throat Passages.

C, nasal cavities; *T*, tongue; *L*, lower jaw; *M*, mouth; *U*, uvula; *E*, epiglottis; *G*, larynx; *O*, gullet, or œsophagus.

Experiment 79. Study the general construction of the throat by the help of a hand mirror. Also examine the throat of some friend.

Experiment 80. *To show the construction of the vocal organs.* Secure and examine the windpipe of a sheep or a calf. It differs somewhat from the vocal organs of the human body, but it will enable us to recognize the different parts which have been described. A suitable specimen can easily be obtained from a butcher.

378. Care of the Throat. Exposed as it is to overheated and unwholesome air, the irritating dust of the street and the workshop, and extremes of heat and cold, it is not strange that the delicate lining of the throat often becomes inflamed. The result is an ailment which is commonly called "sore throat." Almost everybody has at times suffered from it.

Persons subject to sore throat should take great pains to wear proper underclothing. Daily baths are excellent

tonics to the skin, and thus serve indirectly to harden one who is liable to throat ailments even in ordinary changes in the weather.

Muffling the neck in scarfs, furs, and wraps is not a good plan, — it only increases the liability to catch cold, — except, perhaps, during the coldest weather or during unusual exposure to cold.

379. The Larynx. As we have been told in a preceding section, the boxlike top of the windpipe is called the **larynx**, meaning top of the windpipe (Sec. 222).

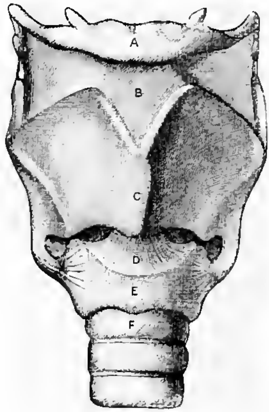

FIG. 173. Cartilages and Ligaments of the Larynx. (Front view.)

A, hyoid bone; *B*, membrane attached to hyoid bone and the shield-shaped cartilage below (thyroid); edges of this shield-shaped cartilage unite at *C* (Adam's apple is the V-shaped groove on a line with *B* and *C*); *D*, membrane between the shield-shaped cartilage and the signet-ring cartilage below; *E*, cricoid, or signet-ring, cartilage; *F*, upper ring of the windpipe.

The sides of this box are made of two flat pieces of cartilage shaped like a shield and known as the **thyroid** cartilage. The edges unite in front and project to form "Adam's apple," which is easily felt and is plainly to be seen on most lean people, especially spare men (Exp. 33, p. 109). The thyroid cartilage shelters the delicate and movable structure within and shields it from injury from without.

The **epiglottis** is attached to the inner and upper part of this cartilage. Just below is a ring-shaped cartilage called the **cricoid.** It is broad behind, quite narrow in front, much like a seal ring. This is easily detected under the skin, a little below "Adam's apple."

Two slender, ladle-shaped cartilages are placed on the top of the back part of the cricoid. They work with a ball-and-socket joint and have tiny muscles which regulate their movements with the utmost accuracy.

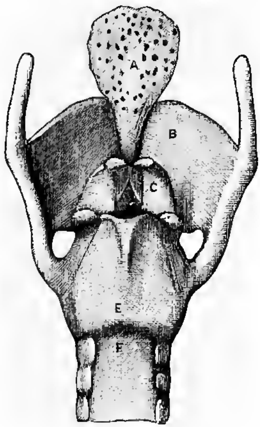

FIG. 174. Cartilages and Ligaments of the Larynx. (Posterior view.)

A, epiglottis; *B*, thyroid cartilage; *C*, ladle-shaped cartilage; *E*, cricoid cartilage; *F*, upper ring of the windpipe.

380. The Vocal Cords. From each of the two ladle-shaped cartilages a band of elastic tissue passes forward and is joined to the inner and front part of the shieldlike cartilage towards its lower edge.

These two bands, called the **vocal cords**, are narrow strips of firm, fibrous material with a chinklike opening between them called the **glottis**, meaning the mouthpiece of a flute. These cords are the real organ of voice.

All the air which goes out of or into the lungs must go through the glottis. There are muscles and cartilages which serve to tighten or loosen these cords. During ordinary breathing the vocal cords are widely separated.

381. How the Voice is produced. If the air is driven out of the lungs by an act of expiration when the cords are in a state of tension, they vibrate and produce the sound called the **voice.**

The different musical sounds produced in singing depend upon the length and the varying degree of tension of the vocal cords. The compass of the voice depends upon the extent to which the variations can take place. A practiced

singer can, at will, give the requisite tension for the production of any particular note.

The quality of a voice depends chiefly upon the shape of the larynx and of the other air passages above it. In women and children the larynx is smaller, and the vocal cords shorter, than in men; consequently their voices have a higher pitch. The larger the larynx and the longer the cords, the deeper the voice.

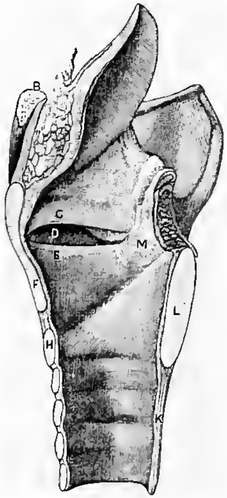

FIG. 175. Arrangement of the Vocal Cords.

A, epiglottis; *B*, section of hyoid bone; *C*, false vocal cords which have nothing to do with the production of voice; *D*, oblong opening between the false and true vocal cords; *E*, true vocal cord; *F*, section of the thyroid cartilage; *H*, section of anterior portion of the cricoid cartilage; *K*, trachea; *L*, section of the posterior portion of the cricoid cartilage; *M*, ladle-shaped cartilage.

Voice may exist without speech, as in many animals. **Speech** is the voice modified by the throat, teeth, palate, nose, tongue, and lips.

NOTE. — The limitations of a text-book on physiology for elementary schools do not permit so full a description of the voice as the subject deserves. For additional details the student is referred to more advanced text-books or to some small manual on the subject, as Cohen's *The Throat and the Voice*, a volume in the American Health Primer Series.

Experiment 81. Pinch the nostrils and try to pronounce slowly the words "Lincoln," "something," or any other words which require the sound of *m*, *ln*, *ng*.

This will illustrate somewhat crudely the importance of the resonating cavity of the nose in articulation.

Experiment 82. Take two strips of India rubber and stretch them over the open end of a boy's bean blower, or any kind of tube. Tie them tightly with thread so that a chink will be left between them, as in Fig. 176.

To illustrate roughly the passage of air through the glottis, force the air through such a tube by blowing hard, and if the strips are not too far apart a sound will be produced. The sound will vary in character according as the bands are made tight or loose.

382. Effect of Tobacco upon the Throat and Lungs. The effect of tobacco upon the throat and lungs is frequently marked and persistent. The smoke is an irritant, both by its temperature and from its destructive ingredients. It irritates and dries the mucous membrane of the mouth and throat, producing an unnatural thirst, which may excite a craving for intoxicating liquors.

FIG. 176.

The irritation of the throat may extend up the Eustachian tubes and impair the hearing.

Again, the breathing in of the poisonous smoke produces unhealthful effects upon the delicate mucous membrane of the bronchial tubes and of the lungs. Upon the former it often produces an irritating cough, with short breath. The pulmonary membrane may be congested; taking cold then becomes easy, and recovery from it is tedious.

The habit of inhaling tobacco smoke, so common with boys who smoke cigarettes, and then forcing it through the nostrils, often causes inflammation of the air passages, throat, and nose. Breathing air laden with tobacco smoke may irritate and inflame the throat. Cigarette smoking itself is irritating to the throat passages.

383. Effect of Alcohol and Tobacco upon the Voice. The peculiar harsh tone of the voice in those given to strong drink is a familiar fact. The reason for it is plain. Alcoholic liquors inflame and irritate the delicate lining of the throat and of the vocal cords. This, after a time, may make the mucous membrane lining thick and rough.

Alcohol may weaken the vocal efforts. Hence, vocalists, clergymen, and public speakers often find that alcoholic drinks impair the voice.

Tobacco affects the vocal cords and to a marked degree may injure the voice. In fact, our best teachers of vocal music do not allow their pupils to use alcoholic liquors and tobacco.[1]

[1] The celebrated throat doctor, the late Sir Morell Mackenzie, of London, strongly objected to cigarettes. These are his words:

"Cigarette smoking is the worst form of tobacco indulgence, from the fact that the very mildness of its action tempts people to smoke nearly all day long, and by inhaling the fumes into their lungs saturate their blood with the poison. It should be borne in mind that there are two bad qualities contained in the fumes of tobacco. One is poisonous nicotine, the other the high temperature of the burning tobacco."

When tobacco is smoked there are developed certain acrid vapors which have an irritant action on the mouth and throat. The effects of smoking are in part due to irritant matters in the smoke. The inflammation often extends to the larynx, or may spread up the Eustachian tubes and impair the hearing. Cigarettes are especially apt to cause these symptoms. Those who draw the smoke into their lungs often suffer from chronic inflammation of the bronchial tubes in consequence. — H. NEWELL MARTIN, M.D.

QUESTIONS ON THE TEXT

1. What is the throat? 2. In what way may we get an idea of the throat? 3. What parts of the throat can we see upon looking into a friend's mouth? 4. What is the pharynx? 5. Give some hints about the care of the throat. 6. Describe the larynx. 7. What is meant by "Adam's apple"? 8. Describe the vocal cords. 9. How is the voice produced? 10. Upon what does the quality of the voice depend? 11. What is the effect of tobacco upon the throat and the lungs? 12. How does cigarette smoking affect the throat passages and the voice? 13. What is the effect of strong drink and tobacco upon the voice?

CHAPTER XIII

FIRST AID IN ACCIDENTS AND EMERGENCIES

384. Frequent Opportunities to give First Aid. We have tried in the preceding chapters to understand a few of the laws of health and to apply them intelligently to our daily living. It will help us to clinch what we have already mastered, if we now supplement our work with a knowledge of simple methods of procedure in case of the more common and less serious accidents and emergencies.

Emergencies and accidents are of frequent occurrence. A playmate may cut his leg or foot with a scythe or knife, or fall and break his arm. A child may accidentally swallow some laudanum, set his own clothing on fire, or push a bean into his nose or ear. A teamster may be brought in with his ears frost-bitten. A small boy may fall into the river and be brought out apparently drowned. Some one of our own family may be taken suddenly sick with some contagious disease or may be suffocated with coal gas.

All these and many other things of a like nature call for a cool head, a steady hand, and some practical knowledge of what is to be done until medical or surgical help is obtained. A fairly good working knowledge of such matters may be easily mastered.

A boy or girl who has acquired this knowledge and who is able to maintain a certain amount of self-control will find many opportunities in after years to lend a hand in the midst of accidents and sudden sickness.

ACCIDENTS AND EMERGENCIES

385. What to do First. All that is expected of us is to tide over matters until the doctor comes. Retain as far as possible presence of mind, or, in other words, keep cool. Act promptly and quietly, but not with haste.

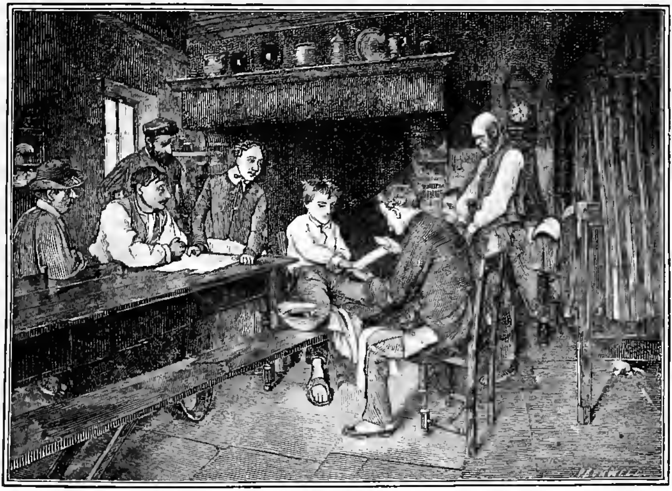

FIG. 177. An Accident.

This striking picture, by a celebrated French artist, has excited marked attention ever since it was first exhibited at the Paris Salon. The grouping is admirable, and by the absence of all accessories the interest is skillfully concentrated on the principal personage, the attending surgeon, and the pale boy whose arm he is bandaging and who is striving not to wince beneath the treatment. That the hurt is not trifling is shown by the basin of blood and the look of concern in the countenances of the surrounding family, who are yet sufficiently composed to indicate that there is no imminent danger. The strongly lined faces of the peasants, with their varying expressions, contrasted with the rude interior, form a graphic study.

The picture is used by the kind permission of William Wood & Co., publishers.

Make the sufferer comfortable by giving him an abundance of fresh air and placing him in a restful position. Loosen all tight articles of clothing, as belts, bindings, corsets, and collars. Be sure to send for a doctor at once if the emergency calls for any such skilled service.

386. What to do for a Fainting Person. A fainting person should be laid flat on his back with his head lower than his feet. Loosen tight clothing. Give plenty of fresh air and sprinkle cold water on the head and neck. Smelling salts may be held to the nose to excite the nerves of sensation and thus stimulate respiration.

When the patient does not become conscious in a few minutes a physician should be called without delay. Remember that in all cases of fainting treatment should be given promptly.

Experiment 83. *To show proper treatment for fainting.* Select several places about the schoolroom, and show exactly how a person should be placed, supposing he has fainted in a crowded room.

387. Epileptic Fits. Nothing can be done to stop **epileptic fits**. Give plenty of fresh air. Unfasten the clothes, especially about the neck and chest. Crowd a pad made from a folded handkerchief or towel between the teeth to prevent the patient from biting his lips or tongue. Do not try to make the sufferer swallow any drink. See to it that he does not injure himself by falling against a hard surface.

388. Hysterics. Attacks of **hysterics** vary in extent from an uncontrollable fit of laughing or crying to convulsions not unlike those of an epileptic character. No treatment is really necessary, as the patient will usually recover promptly if left alone. Sympathy is almost sure to make

bad matters worse. A dash of cold water in the face will sometimes assist recovery.

389. Sunstroke and Heat Exhaustion. The main thing in **sunstroke** is to lower the temperature. Strip off the clothing. Apply chopped ice, wrapped in flannel, to the head. Rub ice over the chest and place pieces under the armpits and at the sides. If there is no ice, apply an abundance of cold water to the head and neck. Sheets or cloths wet with cold water may be used.

If the skin is cold, moist, or clammy, and the pulse weak, the trouble may be due to **heat exhaustion.** Give plenty of fresh air, but apply no cold to the body. Rest in bed is necessary. Apply heat and give hot drinks.

390. Clothing on Fire. Throw the person down on the ground or floor, as then the flames will not tend to rise toward the mouth and nostrils. Without a moment's delay roll the patient in a carpet or rug so as to stifle the flames, leaving only the head out for breathing. If no carpet or rug can be had, use a coat or cloak.

391. Burns and Scalds. Remove the clothing in cases of **scalds** and **burns** with the greatest care. Do not pull off the clothes from the burned places, but gently loosen them or cut them away bit by bit with a pair of sharp scissors. Save the skin unbroken if possible, taking care not to break the blisters. The aim is to prevent friction, to keep out the air, and to relieve pain.

In burns caused by *acids* bathe the parts gently with an *alkaline* fluid, as diluted ammonia or strong soda in solution, and afterwards dress the burn.

In burns caused by *alkalies,* as lime and caustic potash, apply *acids,* such as lemon juice or vinegar diluted with water.

If the burn is slight, put on strips of soft linen soaked in a strong solution of baking soda and water, one heaping tablespoonful to a cupful of water. This is especially good for scalds. If carbolized or even plain vaseline is at hand, spread it freely on strips of old linen and cover well the burnt parts, keeping out the air with other strips carefully laid on.

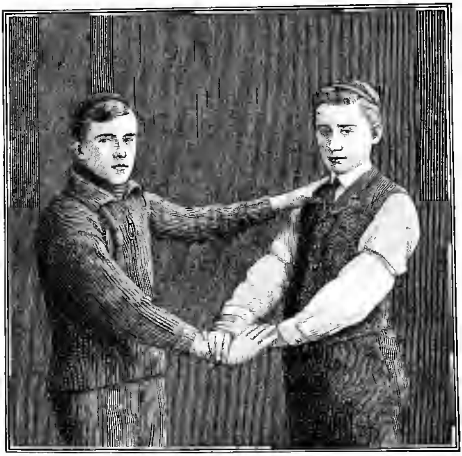

FIG. 178. Improvised Hand Seats: the Three-Handed Seat.

The useful three-handed seat is made by one bearer grasping the free wrist of the other bearer and placing his free hand on his partner's shoulder, in order to support the patient's back.

Burns and scalds are dangerous in proportion to their extent and depth. A deep or extensive burn or scald should always have prompt medical attendance.

A mixture made by shaking together until creamy equal parts of linseed oil and limewater, and commonly known as **Carron oil,** is one of the best local applications for burns. Soak strips of old linen or absorbent cotton in this time-honored remedy and gently apply to the burnt parts, taking care to use more of the mixture as the strips become dry.

Experiment 84. Have a small quantity of soda, linseed oil, and limewater in the schoolroom. Imagine a pupil has burned his arm or hand. Show exactly what is to be done and how.

392. Frostbites. Rub the frozen parts vigorously with snow or snow water in a cold room. Continue this until a burning, tingling pain is felt, when all active treatment should cease. Pain shows that warmth and circulation are beginning to return. No warm air, warm water, or fire should be allowed near the frozen or frost-bitten parts until the natural temperature is nearly restored.

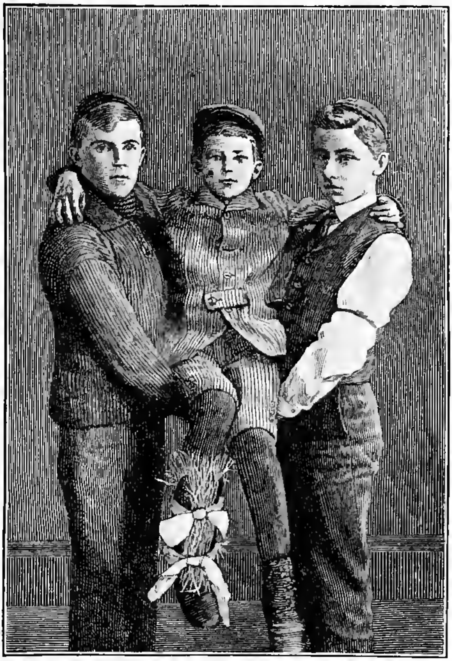

FIG. 179. Showing how the Improvised Three-Handed Seat may be used to carry an Injured Person (Sec. 405).

The picture also shows how a boy's broken leg may be treated with an improvised apparatus made of two pieces of oak bark for splints, padded with grass and held in place by two pocket handkerchiefs.

393. Dog Bites. There is not much more danger from the bite of a dog that is not "mad," that is, not suffering from the disease called *rabies*, than there is from any other lacerated wound. As a rule, the bites of animals, such as cats and rats, are painful and liable to be poisonous. A bite from a dog that is really "mad" is a rare accident, which demands prompt and fearless treatment.

A mad-dog bite is really a lacerated wound. In the little roughnesses, and between the shreds, may be poisonous saliva. If these projections and depressions affording the lodgment can be removed, the poison may not do much harm. If done with a knife, the wound would be converted, practically, into a cut wound, and would require treatment for such.[1]

Remove the clothing at once from the bitten part, and apply a temporary ligature *above* the wound. This interrupts the activity of the circulation of the part, and to that extent may delay, or even prevent, the absorption of the poisonous saliva.

If the wound is at once well cleansed with antiseptic washes, and a stick of solid nitrate of silver (lunar caustic) rapidly applied to the entire surface, the danger of blood poisoning is greatly diminished.

Poultices, kept hot and moist with antiseptic solutions, may be applied to the injured parts to hasten the sloughing away of the tissues whose vitality has been intentionally destroyed.

If a physician is at hand, he will probably cut out the injured portion, or cauterize it thoroughly. A doctor's help is not always at our command. In such a case it would be a safe, and by no means a painful, procedure to take a poker, or other suitable piece of iron, heat it red hot, and cauterize the entire surface of the wound.

[1] Any dog, after having bit a person, is apt, under a mistaken belief, to be at once killed. This should not be done. The suspected animal should be immediately placed in confinement and watched, under proper safeguards, for the appearance of any symptoms that indicate rabies. Should no pronounced symptoms indicate this disease in the dog, a great deal of unnecessary mental distress and worry can be saved both the person bitten and his friends.

394. Stings by Venomous Insects, as Bees and Wasps. Remove the sting if it can be seen. Vinegar and water, dilute ammonia, alcohol, or cologne water will give much relief. Moist earth or cold water if applied at once will afford some relief.

In stings from plants, nettles, etc., great relief will be given by the prompt application of a dilute solution of ammonia or of baking soda.

395. Bleeding from the Nose. Let the patient sit upright. Raise the arm on the bleeding side above the head. Do not blow the nose. Wring out two towels in cold water; wrap one around the neck and the other properly folded over the forehead and upper part of the nose. In severe cases, put the feet in water as warm as can be borne. Plug the nostril with a piece of absorbent cotton which has been wet with strong borax or alum water.

When the nostril has been plugged, especially if the patient is a young child, it is important to make sure that blood is not trickling down into the throat from the back of the nose.

396. Foreign Bodies in the Nose. Young children are apt to push beans, peas, fruit stones, buttons, and other small objects into their own nose or that of some playmate. The child may usually be made to expel the object by blowing the nose hard while the clear side is closed by pressure with the fingers. At other times a sharp blow between the shoulders will cause the body to fall out. A hairpin, which has been first straightened and then bent into a small hook at one end, may be gently used to remove foreign objects from the ear and the nose.

397. Foreign Bodies in the Throat. Bits of food or other small objects sometimes lodge in the throat, and are easily

extracted by the forefinger, or they may be forced out of the passages by prompt and vigorous slaps on the back.

If the object has actually passed into the windpipe, causing sudden fits of spasmodic coughing, with a dusky hue of the face and fingers, surgical help must be called without delay.

If small objects, like coins, pencils, keys, nails, buttons, etc., are swallowed, it is not necessary to take physic. Hard-boiled eggs, cheese, and potatoes should be freely eaten, so that the intruding substance may be infolded in a mass of solid food and carried safely through the bowels.

The back of the throat should be examined in a strong light, for the body may be arrested at the entrance to the gullet, and, if seen, can often be dislodged by the fingers or some improvised instrument.

398. Foreign Bodies in the Ear. Children sometimes push into the ear such small articles as grains of corn, buttons, pebbles, or beans. Syringe in a little warm water, which will often wash out any substance which is not likely to swell. If the substance, however, is likely to swell, do not syringe the ear, but try to remove the foreign body by gently extracting it with some homemade apparatus.

If live insects get into the ear, drop in a little sweet oil, glycerin, melted vaseline, or warm sirup. If the tip of the ear is pulled up gently, the liquid will flow in more readily. If a light is held close to the outside of the ear, the insect may be coaxed to crawl out, being attracted by the bright flame.

399. Foreign Bodies in the Eye. Cinders, particles of dust, bits of metal, and other small bodies may get into the eye and cause much pain. Never rub the eye. Hold the lid away from the eyeball and the tears will usually wash

the substance away. Dash water with the hand into the eye when the lids are gently pulled apart.

Sometimes the upper lid must be turned back. This is usually done as follows. Seize the lashes between the thumb and forefinger and draw the edge of the lid away from the eyeball. Now, telling the patient to look down, press a slender lead pencil or penholder against the lid, parallel to and above the edge, and then pull the edge up and turn it over the pencil by means of the lashes.

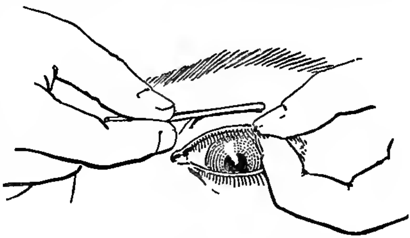

FIG. 180.

Showing how the upper eyelid may be everted with a pencil or penholder.

The eye is now examined readily, and usually the foreign body may be seen and easily removed with the corner of a pocket handkerchief. After the substance has been removed, bathe the eye for some time with hot water to soothe the local irritation. This irritation often gives rise to the feeling that the foreign substance still remains in the eye.

400. Contusions and Bruises. An injury to the soft tissues, caused by a blow, squeeze, or pinch from some instrument, or by a fall, is a **contusion** or **bruise**. A black eye, black and blue spots, an injury caused by a fall from a bicycle, and a finger hurt by a baseball are familiar examples of injuries which ordinarily require simple treatment.

Wring out old towels or pieces of flannel in hot water and apply to the parts, changing as they become cool. For cold applications, cloths wet with equal parts of water and vinegar, or witch-hazel may be used.

When wounds are made with ragged edges, such as broken glass and splinters, more skill is called for. Remove every bit of the foreign substance. If the skin about the wound seems to need washing, it should be done with an antiseptic solution. Bring the torn edges together and hold them in place with strips of plaster.

Wounds made by rusty nails and tools, if neglected, often lead to serious results from blood poisoning. Keep such wounds clean by washing or syringing them twice a day with antiseptics which kill the bacteria or prevent their growth.

Deaths following injuries from toy pistols and percussion caps have become so frequent in recent years that it is not safe to depend upon home treatment for such accidents. All such wounds should be treated at once by skilled physicians.

FIG. 181.

Showing how a square knot may be tied with a handkerchief (Exp. 87).

Experiment 85. *To show the proper way of treating cuts and bruises.* Let red-pencil marks made on the face, arms, fingers, etc., stand for cuts. Apply suitable strips of plaster in a proper way for a variety of imaginary cuts. After putting on the plaster, practice bandaging the parts with strips of cotton cloth rolled for the purpose. Practice using the handkerchief for a variety of bandages.

401. Injuries to the Blood Vessels. It is very important to know the difference between the bleeding from an artery and that from a vein. If an **artery** bleeds, the **blood leaps in spurts** and is of a **scarlet** color. If a **vein** bleeds, the blood **oozes in a steady stream** and is of a somewhat **darker** color.

Bleeding from an artery is dangerous in proportion to the size of the vessel, and as a result life itself may be speedily lost. In arterial bleeding, always **remember to make deep pressure between the wound and the heart.**

402. What to do First. Do not be afraid to act at once. A resolute grip in the right place with firm fingers will do well enough until a knotted handkerchief, stout cord, shoe string, or an improvised tourniquet[1] is ready to take its place. If the flow of blood does not stop, change the pressure until the right spot is found.

FIG. 182.

Showing how an improvised apparatus, or temporary tourniquet, may be adapted to arrest bleeding from an artery in the arm. This apparatus consists of half of a potato held in place over the artery by a pocket handkerchief used as a band. A stick, picked up on the ground, is inserted beneath the band on the opposite side of the limb and used as a lever to press the potato firmly against the artery.

403. Where and how to apply Pressure. The principal places in which to apply pressure when arteries are injured and bleeding should always be kept in mind.

If in the **finger**, grasp it with the thumb and forefinger and pinch it firmly on each side; if in the hand, press on the

[1] A tourniquet is a bandage, handkerchief, or strap of webbing into the middle of which a stone, a potato, a small block of wood, or any hard, smooth body is tied. The band is tied loosely about the limb, the hard body is held over the artery to be constricted, and a stick is inserted beneath the band on the opposite side of the limb and used to twist the band in such a way that the limb is tightly constricted thereby, and the hard body thus made to compress the artery.

bleeding spot, or grasp firmly with the fingers just above and on both sides of the wrist.

For injuries **below the elbow**, grasp the upper part of the arm with the hands and squeeze hard. The main artery runs in the middle line of the bend of the elbow. Tie a knotted handkerchief or cord here and bend the forearm so as to press hard against the knot.

FIG. 183.

Showing how firm pressure may be made with the fingers to compress the brachial artery of the left arm. Some large superficial veins are also shown.

For the **upper arm**, press with the fingers against the bone on the inner side and just on the edge of the bulging part of the biceps muscle. Take a stout stick of wood about a foot long and twist the cord hard with it, bringing the knot firmly over the artery (Fig. 190).

For the **foot** or **leg**, use pressure, as before, in the hollow behind the knee just above the calf of the leg. Bend the thigh towards the abdomen and bring the leg up against the thigh, with the knot in the bend of the knee.

Experiment 86. *To stop bleeding from the arteries.* Locate the principal arteries on your own person and that of a friend. Let red-crayon or red-pencil marks stand for the course of the arteries.

Now, with strings, cords, shoe strings, handkerchiefs, or strips of clothing, practice tying them so as to press deeply and firmly in the proper place. Let each one in the class practice on the same artery. Criticise and improve one another's work.

404. Bleeding from the Lungs. Blood that comes from the lungs is bright red and frothy. There is rarely much blood; it usually follows coughing, feels warm, and has a salty taste.

Bleeding from the lungs, or pulmonary hemorrhage, is a grave symptom. A doctor should be called at once. The patient should be made to lie down with the head and shoulders slightly raised. Perfect rest and quiet must be insisted upon. Finely chopped ice may be eaten to relieve thirst. Loosen the clothing, keeping the shoulders well raised and the body in a reclining position.

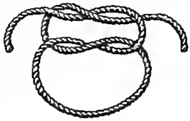

FIG. 184.

Showing how a square knot may be tied with a cord.

Experiment 87. *How to tie a square knot.* With a handkerchief, a shoe string, a roller bandage, or cords of various sizes, practice tying a square knot until it can be done accurately and rapidly.

A square knot[1] is tied by holding an end of a bandage or cord in each hand, and then passing the end in the *right* hand over the one in the left and tying; the end now in the *left* hand is passed over the one in the right and again tied (Fig. 181).

405. Broken Bones. Parts of the body which have sustained a **break** or **fracture** of one or more bones should be handled with great care and tenderness. The most important signs of a broken bone are the fact of an accident having occurred of sufficient severity to break the bone, pain at a certain fixed point, the inability to bend the limb or move the bone in a natural position, and the grating

[1] If the student would render efficient help in accidents and emergencies, to say nothing of service on many other occasions, he must learn how to tie a square, or "reef," knot. This knot is secure and does not slip, as does the "granny" knot. The square knot is the one used by surgeons in ligating vessels and securing bandages. Unless one knows the difference, the insecure "granny" knot may be substituted.

sensation which may be felt or heard at the point of injury. Never move the injured person until the limb is made safe from further injuries by putting on temporary splints. If you do not need to move the person, keep the limb perfectly quiet and in a natural, comfortable position until the doctor comes. If the accident happens in the woods, the limb should be bound with handkerchiefs or strips of clothing to a piece of board, pasteboard, or bark, padded with moss or grass, which will do well enough for a temporary splint (Fig. 179).

Send for a doctor at once to set the broken bone (Figs. 30–32).

FIG. 185.

Showing how an improvised apparatus may be used for a broken radius. This temporary dressing consists of two pieces of oak bark for splints, with grass for padding, and is secured in place by a boy's long stocking and a pocket handkerchief.

Experiment 88. *To carry an injured person.* Take some one of the small boys and show how he should be carried in a three-handed seat in case of injury.

406. Sprains. The wrenching or tearing of the ligaments about a joint is called a **sprain.** Sprains are often acquired in the course of outdoor sports. Thus, sprains of the fingers are common enough with baseball players. There is at once pain on movement and swelling.

Keep the injured parts at rest and soak them in water as hot as can be borne. Continue the treatment for several hours if necessary, until the pain and swelling have been reduced. Cold water is often used, but hot water is better. If prompt relief is not afforded, secure the services of a doctor. A crippled or weak joint may result from lack of prompt and proper treatment of a sprain.

407. Asphyxia, or Suffocation. The chief dangers from poisoning by noxious gases come from the fumes of burning coal in the furnace, stove, or range; from blowing

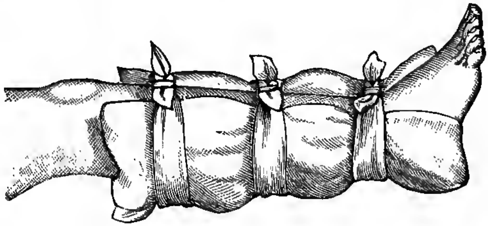

FIG. 186.

Showing how a pillow, an inside coat, a "sweater," or a blanket may be used as a temporary splint on a broken leg.

out gas or turning it down and having it blown out by a draught; from the foul air often found in old wells or mines; and from the fumes of burning charcoal.

The first and essential thing to do is to give fresh air. Remove the person to the open air and place him on his back. Remove tight clothing about the throat and waist, and dash cold water on the face and chest. As soon as the patient can swallow, give hot coffee or hot ginger tea.

Friction applied to the limbs should be kept up. If breathing has ceased or is very feeble, artificial respiration must be begun at once and the doctor sent for (Sec. 409).

408. What to do in Apparent Drowning. Remove all tight clothing from the neck, chest, and waist. Sweep the forefinger, covered with a handkerchief or towel, round the mouth to free it from froth and mucus. Turn the body on the face, raising it a little with the hands under the hips to allow any water to run out from the air passages. Take only a moment for this.

Lay the person flat upon the back, with a folded coat or pad of any kind to keep the shoulders raised a little. Remove the wet, clinging clothing as soon as possible. If

FIG. 187. Production of Artificial Respiration.

First movement — inspiration.

in a room or sheltered place, strip the body and wrap it in blankets, overcoats, etc. If possible, use bottles of hot water, hot flatirons, or bags of hot sand round the limbs

and feet. Watch the tongue; it generally tends to slip back and to shut off the air from the glottis. Wrap a coarse towel round the tip of the tongue and keep it well

FIG. 188. Production of Artificial Respiration.

Second movement — expiration.

pulled forward. The first sign of recovery is often seen in the slight pinkish tinge of the lips or finger nails. That the pulse cannot be felt at the wrist is of little value in itself as a sign of death. Life may be present when only the most experienced ear can detect the heart beat.

When a person can breathe even a little he can swallow. Give a few teaspoonfuls at a time of hot black coffee or hot ginger tea. Hold smelling salts or hartshorn to the nose. Meanwhile do not fail to keep up artificial warmth in the most vigorous manner.

409. How to produce Artificial Respiration. The main thing to do in apparent drowning, or in other cases of suspended animation, is to produce **artificial respiration** until the natural breathing comes or all hope is lost. This is the simplest way to do it. The person lies on the back. Let some one kneel behind the head. Grasp both arms near the elbows and sweep them upward above the head until they nearly touch. Make a firm pull for a moment. This tends to fill the lungs with air by drawing the ribs up and making the chest cavity larger. Now return the arms to the sides of the body until they press hard against the ribs. This tends to force out the air and makes a complete act of artificial respiration. Repeat this act about fifteen times every minute for several hours if necessary.

Experiment 89. *To illustrate proper treatment for apparent drowning.* Show exactly how artificial respiration is done. Let a boy lie on the floor or settee, and illustrate the process in every detail. It would be an excellent idea for a teacher to meet his boys at their bathing place, or even on the playground, and instruct them more freely concerning every step in the treatment.

Let two boys go through the process on a playmate under the eye of the teacher; then others may follow their example.

POISONS AND THEIR ANTIDOTES

410. Careless Use of Poisons. Poisons of various kinds are quite generally used in the trades and kept about the house and premises as medicines, as disinfectants for killing insects and rats, and for many other purposes.

People are often careless about poisons and leave them wrapped in a piece of paper or in some unlabeled bottle, or even in a cupboard or on a shelf in a kitchen closet,

shed, or stable. Children either mistake them or are sometimes urged by a playmate to swallow the contents of some bottle or package.

The many fatal accidents due to drinking carbolic acid or aconite by mistake may serve as a familiar example of how stupid or careless people may be.

411. How to prevent the Improper Use of Poisons. All poisons should always be put in bottles carefully labeled, and the word POISON should be plainly printed in large letters directly across the label. Fasten the cork firmly to the bottle by wire picture cord or copper wire twisted into a knot at the top. This simple precaution would certainly prevent a person from mistaking, in the dark, carbolic acid, oxalic acid, etc., for medicine.

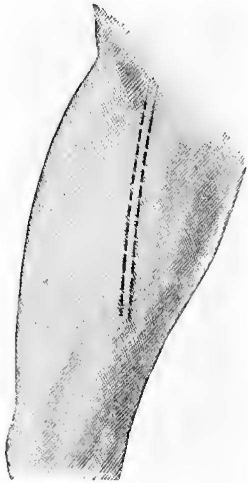

FIG. 189. BLACKBOARD SKETCH.

The dotted line shows the course of the right femoral artery.

Poison should never be kept in the same place with medicines or other bottled preparations used in the household. Put them in some secure place and under lock and key.

Another very simple rule is never to use the contents of any package or bottle unless you know exactly what it is. Do not guess at it or take any chances, but destroy it at once.

412. Some Common Emetics. Poisons are often taken when medical help, especially in the country, cannot be had at short notice. They often do their work rapidly. Something must be done to counteract them, and that at once and in earnest.

For most poisons, the stomach should be emptied as speedily as possible. Make a quart of warm soapsuds. Force the sufferer to gulp it down, a cupful at a time. Run the finger down the throat and hasten the vomiting.

A good **emetic** is made by stirring a heaping tablespoonful of ground mustard in a pint of warm water. Give a cupful every ten minutes until vomiting is produced. Common salt may be used in place of mustard. Stir a handful of powdered alum into a cupful of sirup and give a tablespoonful every ten minutes. It affords a prompt emetic.

Be in earnest about it and do not waste time to see if the poisoned person likes such treatment. Vomiting will not do any harm. Remember that the poison may destroy life in a few minutes.

413. Different Kinds of Poison. For convenience, the more common poisons may be arranged in different classes.

Some poisons are *acids*, like the **oil of vitriol**; others are *alkalies*, like **lye**.

Some poisons are irritant *mineral* poisons, like **arsenic** or **sugar of lead**; while others are *vegetable* poisons, like **monkshood** and **wild parsnip**.

We can easily remember the general plan of treatment for each special class of the more common poisons.

414. Acid Poisons and their Antidotes. The **oil of vitriol, nitric acid,** and **muriatic acid** are in common use in certain workshops and are occasionally used in the household. These are caustic mineral acids that rapidly burn and destroy the living tissues.

Give an alkali. Give large quantities of strong soapsuds, chalk, tooth powder, soda or saleratus water, magnesia, or limewater. Scrape off the whiting from the wall

or dig out a piece of plaster. Dilute it with large quantities of water and give the mixture. Follow this treatment with some mild, soothing tea made of flaxseed or Irish moss.

Oxalic acid is often mistaken for granulated sugar or Epsom salts. For an antidote use chalk, whitewash, plaster, etc., as before.

Carbolic acid in solution is very commonly used about the house. It is a highly dangerous poison and generally fatal. Provoke vomiting by giving large quantities of soapsuds and sweet oil mixed together. Follow with large draughts of sweet oil or milk. Large doses of Epsom salts may be used.

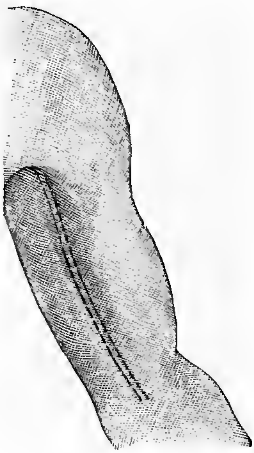

FIG. 190. BLACKBOARD SKETCH.

The dotted line shows the course of the left brachial artery.

415. Alkaline Poisons and their Antidotes. The common **alkalies** taken as poisons are **ammonia, potash,** and **soda,** usually dissolved but often in the form of lye. In addition to other poisons, horse liniments and other liniments generally contain ammonia. They are often taken by mistake. Alkalies burn the mucous membranes rapidly and severely.

Give acids. Give vinegar freely. Lemon juice may be used. Large quantities of sweet oil, linseed oil, and castor oil may be given.

416. Metallic Poisons and their Antidotes. **Arsenic** is a white, sweetish powder often used to kill rats. It is occasionally taken by mistake. **Paris green** is a form of arsenic used by farmers. Arsenic is also found in ratsbane and the various kinds of powder used to kill flies.

Provoke vomiting at once. Give large quantities of milk, the whites of eggs, flour and water, or oil and limewater.

In **sugar of lead** poisoning, provoke vomiting and give Epsom salts.

In **copper** poisoning by blue vitriol and verdigris, use milk or white of eggs followed by flaxseed tea.

Use the same treatment in **mercurial** poisoning, occasioned by drinking solutions of *corrosive sublimate*, which is chiefly used as a disinfectant.

Children sometimes eat the **phosphorus** from matches. Use plenty of magnesia, chalk, or whiting, but no oil. This poison acts slowly and usually there is time enough to get medical help.

417. The Various Forms of Opium as Poisons. The various forms of **opium** are often taken by mistake or in an overdose. The narcotic effects of laudanum, paregoric, Dover's powder, most cholera mixtures, and many of the so-called "soothing sirups" and "drops" are due to opium.

Brisk emetics must be used until they act thoroughly. Give plenty of hot, strong coffee without milk or sugar. Do not allow the patient to fall into a deep sleep. Dash cold water over the head and shoulders and slap the skin briskly with wet towels or with a slipper. Medical help must be called at once.

NOTE. — The teacher or student who is disposed to study the several topics of this chapter in more detail than is possible in an elementary text-book may find the necessary material in the following books. They are readily obtained of booksellers or may be found in the public libraries of larger towns: Dulles' *Accidents and Emergencies* (price $1.00); Pilcher's *First Aid in Illness and Injury* (price $2.00); Doty's *Prompt Aid to the Injured* (price $1.50), and Drinkwater's *First Aid to the Injured* (Temple-Primer Series; price 50 cents).

418. Poisonous Plants. There are certain **poisonous plants** occasionally eaten by children and others which often produce serious and sometimes fatal results. Children are somewhat disposed to "dare" their playmates to eat of plants which they find in their walks.

We have space to refer to only a few of the most common poisonous plants.

Water hemlock, commonly known as wild parsnip, cowbane, etc., is poisonous.

Aconite, otherwise known as monkshood and wolfsbane, might be mistaken for horse-radish. It is a dangerously poisonous plant. Several species of **lobelia** are poisonous, as the large lobelia with its blue blossoms, the **cardinal flower** with its tall spike of red flowers, and the well-known **Indian tobacco.**

Several varieties of **toadstools** are poisonous and are occasionally mistaken for edible mushrooms. All parts of the **poison sumac** (poison dogwood, poison elder) are dangerous.

Children should be taught to know what particular fruits, seeds, and flowers of plants are poisonous.

Most persons are susceptible even to the touch of **poison ivy,** all parts of which, especially its juice, are poisonous. A few other plants, as **poison dogwood** and **stramonium plant,** are also poisonous to the touch.

Give emetics that will produce prompt and brisk vomiting for poisoning from eating plants. Stimulating drinks and purgatives are usually indicated.

Inasmuch as most vegetable poisons act promptly and the treatment is difficult in many cases, the services of a physician are usually needed without delay.

QUESTIONS ON THE TEXT

1. How may we supplement what we have learned in the preceding chapters? 2. What are some of the more common accidents and emergencies that may occur at any moment? 3. What are some of the things that we should do first? 4. What should be done for a fainting person? 5. Describe the treatment for epileptic fits. 6. What would you do for hysterics? 7. Describe the treatment for sunstroke and heat exhaustion. 8. Mention some things to be done when the clothing is set on fire. 9. Describe the treatment for burns and scalds. 10. What may be done for frostbites?

11. Describe in some detail the nature and treatment of dog bites. 12. What is to be done for bleeding from the nose. 13. Describe the treatment for foreign bodies in the nose; in the throat; in the ear; in the eye. 14. Show what may be done for contusions and bruises. 15. How would you know the difference between bleeding from an artery and that from a vein? 16. What is the chief thing to do for arterial bleeding? 17. How should pressure be applied to stop bleeding, at the fingers? below the elbow? on the upper arm? on the foot or leg? 18. What would you do for bleeding from the lungs? 19. Describe in some detail the treatment for broken bones. 20. What should be done for sprains?

21. What is the first and essential thing to do in cases of suffocation? 22. Describe fully what to do for apparent drowning. 23. Describe the process of producing artificial respiration. 24. How may the improper use of poisons be prevented? 25. Describe a few of the more common emetics. 26. What are some of the more common acid poisons and their antidotes? 27. Name the alkaline poisons and their antidotes. 28. Mention a few metallic poisons, giving their antidotes. 29. What are the more common forms of opium? 30. What should be done for opium poisoning?

31. Mention some of the more common poisonous plants. 32. What is the general treatment in cases of accidental poisoning from plants?

CHAPTER XIV

BACTERIA; DISEASES THAT SPREAD AND DISINFECTANTS; CARE OF THE SICK ROOM

419. The Work done by Bacteria. We all know that in hot weather milk, meat, and every kind of moist food quickly becomes bad. In a previous chapter we learned that a glass of sweetened water or sweet cider, if left in a warm place, soon begins to ferment or "work" (Chapter V). Everybody knows that if the dead body of some animal is buried in the ground, it soon begins to putrefy and after a time almost entirely disappears.

All these and countless other wonderful changes in dead organic matter, known as **putrefaction** or **fermentation**, are due to the work done by myriads of living organisms called **bacteria**. The terms **germs**, **microörganisms**, and **microbes** are commonly applied to certain low forms of plant and animal life of microscopic size. Probably there are microörganisms that cannot be seen even with the help of the highest power of the microscope.

420. Nature and Propagation of Bacteria. Bacteria are low forms of plant life which appear as the tiniest bright rods or dots when examined with a microscope of great power.

When bacteria gain an entrance into fluid suitable for their growth they multiply by division with incredible rapidity. Thus, in a cupful of milk in the course of one hot night millions upon millions of bacteria may develop.

Under certain conditions bacteria reproduce themselves by minute round bodies called "spores" or eggs. These spores become dried without losing their vitality, and as dust may be carried everywhere by the winds. Under favorable conditions they germinate and become bacteria.[1]

421. Importance of Bacteria in Nature. Bacteria exist in the soil and in water. They are wafted as dust in the air all over the face of the earth. We eat myriads of them in our food, drink them in water, and breathe them in the dust of the street, the house, and the workshop. These tiny organisms break down all dead organic matter into simple chemical substances which are thus made more fit for the food of plants. In other words, bacteria act as scavengers which serve to make the face of the earth clean and sweet for all living things. If it were not so, life upon the earth would be impossible. Like countless other species of living organisms, bacteria obey the relentless law of nature which allows only the fittest to survive. The rains, the winds,

FIG. 191. Various Forms of Bacteria.

Magnified about 1000 diameters.

A, spheroidal bacteria in pairs; *B*, same kind of bacteria in chains; *C*, bacteria found in pus (grouped in masses like a bunch of grapes).

[1] Bacteria consist of many varieties roughly divided into groups according as they are spherical, rodlike, or spiral in shape. The word "bacillus" is commonly applied to rod-shaped bacteria. Each bacterium consists of a mass of protoplasm surrounded by an ill-defined cell wall.

The bacteria vary considerably in size. Some of the rod-shaped varieties are from $\frac{1}{12000}$ to $\frac{1}{8000}$ of an inch in length and average about $\frac{1}{50000}$ of an inch in diameter. It has been calculated that a cubic space of $\frac{1}{25}$ of an inch would contain 250,000,000 of these minute organisms and that they would not weigh more than $\frac{8}{200}$ of a grain.

melting snow and ice scatter them far and wide over the land and sea and destroy many of them.

422. Disease-Producing Bacteria. Many kinds of bacteria are harmless to our bodies, while others under certain conditions are the cause of sickness and death. Thus, diphtheria, typhoid fever, consumption, and probably other diseases may be produced through the agency of certain kinds of bacteria.

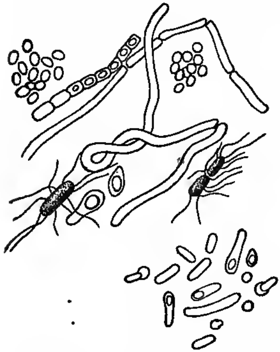

FIG. 192. A Group of Soil Bacteria.

Surface soils abound in many species of microörganisms which may retain their vitality and virulence for a long time. Thus, one experimenter kept some typhoid fever bacteria alive in polluted soil for four hundred and fifty-six days. The disease called "lockjaw" is known to be due to germs occurring in the soil of certain localities (Fig. 199).

It is a mistake to think that a cut of the thumb or great toe is more likely to be followed by lockjaw than is a cut elsewhere. The germs of lockjaw may enter any open wound.

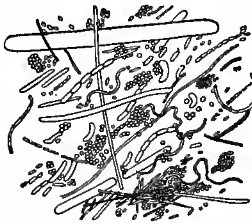

FIG. 193. Scrapings from the Teeth, containing Several Different Kinds of Bacteria. Highly magnified.

423. Bacteria in Food. Food, both good and bad, abounds in bacteria. Fortunately not all bacteria are harmful and many that are harmful are destroyed in cooking. The typhoid fever germ has been traced to ice, ice cream, and raw oysters that were fattened in salt water polluted with sewage. Bacteria have a special

fondness for milk and its various products, which are therefore liable to be polluted in many different ways.[1]

424. How Bacteria gain Access to the Body. The germs of disease may gain access to our bodies in several different ways. Thus, one kind of bacteria requires a break in the skin in order to do harm. This mode of entrance to the body is called **inoculation.** This may result from using soiled instruments or tools, from gunshot injuries made by broken glass or rusty nails, and from numerous other causes. Death has resulted under certain conditions from the scratch of a pin or even the prick of a penknife or the point of a pair of scissors.

Germs of disease may be carried by contact between healthy and diseased persons. This is known as **contagion.** Thus, the microscopic form of vegetable parasite causing ringworm is a familiar example of germs which have been carried by means of a razor or a soiled towel, or which come from handling a stray cat infected

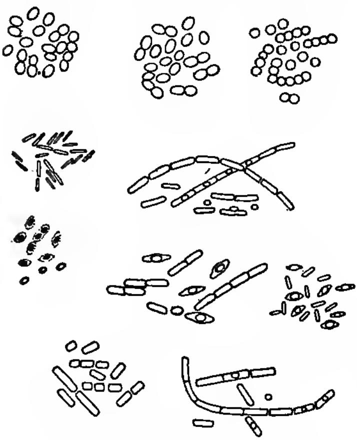

FIG. 194. Different Kinds of Milk Bacteria.

[1] It is not uncommon for a large number of persons to be poisoned from eating ice cream at some public gathering. This is caused by a change in the milk brought about by the presence of bacteria. The poisonous product of their action called "tyrotoxicon" may also be found in other foods which have milk as their basis, such as cheese, custard, and so on. There are vomiting and purging within a few hours after eating the food, succeeded by great nervous prostration, from which recovery follows slowly.

with the same disease.[1] It has been discovered that flies and mosquitoes sometimes carry the germs of disease from one person to another.[2]

Again, disease-producing bacteria, as we have learned, may enter the body with the air we breathe, the food we eat, and the water we drink. Thus, as we have seen, the air may be infected with poisonous germs from the dust of dried sputa (Sec. 237).

[1] Ringworm may occur anywhere on the body, but is perhaps most common on the scalp and face. When found on the bearded parts of the face it is called "barber's itch."

Although ringworm of the face is usually a slight affair, it ought always to be cured as speedily as possible, for it is highly contagious. A child with ringworm should be kept away from school, should sleep alone, and should have special towels, soap, and hair-brush, which the other children in the family should under no circumstances be allowed to use.

FIG. 195. A Piece of Hair from the Scalp infested with a Mold which produces Ringworm.

[2] During recent years it has been discovered that many insects, supposed to be harmless, afford one of the ways in which infection may occur. During the Spanish-American war of 1898 it was proved that typhoid fever was spread through the camps by the agency of flies.

These insects, bearing typhoid germs on their feet, would fly to the camp kitchens and there leave the germs on the food prepared for the soldiers. The prevalence of this "camp fever" among troops encamped in high and seemingly healthful regions puzzled the attending surgeons until the true explanation was discovered.

The mosquito is another insect known to transmit certain diseases; indeed, it is believed by many to be the principal agent in the spread of yellow fever and malaria. It does not carry the germs on its feet, as the fly does, but within itself and on its proboscis. It first stings a sick person, taking in the germs with the victim's blood, and then when it next stings a healthy person the germs are communicated to the blood and there develop in great numbers and excite an attack of the disease.

In India, it has been found that flies carry cholera germs in the same way, wiping them from their feet on food; and it is quite probable that they may carry the germs of dysentery, consumption, and other diseases.

The harmful results produced by bacteria vary greatly in kind and severity. Thus, the germs of consumption may take years to cause fatal results, while those of Asiatic cholera, malignant pustule, and diphtheria may destroy life within a few hours.[1]

425. How Bacteria may act in the Body. Bacteria act in the body in a twofold way.

First, **the germs themselves multiply in the body with incredible rapidity.**

Second, the **products of bacteria,** or their **toxins,** as they are called, **may act their part and bring about a condition of poisoning.**

Thus, the typhoid bacilli, contained in drinking water polluted with wastes from the bodies of those who have had typhoid fever, may multiply in the body for two weeks or more (during what is called the "period of incubation"), but at the end of a limited time the typhoid toxins assert themselves and symptoms of disease appear. The toxins of bacteria may enter the general blood current and poison the entire system.

FIG. 196. Bacilli, or Rod-Shaped Bacteria.

Magnified about 1000 diameters.

From a culture obtained in anthrax, or malignant pustule, of the face. Diseased hides carry this micro-organism and thus may occasion this fatal disease among those who handle hides and wool.

The form of poisoning resulting from the presence in the

[1] The proper relationship between the diseases from which man suffers and those to which animals are liable is interesting and important. Cats, rabbits, and dogs, as well as children, suffer from diphtheria and scarlet fever. Animals may acquire these diseases from sick children and in turn transmit them to healthy children. Both man and the lower animals suffer from tuberculosis.

Among the diseases belonging especially to animals, but which may also be contracted by men, are hydrophobia, anthrax or malignant pustule, glanders, and foot-and-mouth disease.

FIG. 197. Pasteur's Midnight Vision.

This picture is based upon a photograph of a painting which has won great fame during recent years. The artist has represented Pasteur, the celebrated scientist, busily at work in his laboratory, recording the results of his microscopical study of bacteria. As the great master of modern science rests for a moment from his midnight researches, he appears to see in vision the victims of pestilence, famine, and infectious diseases imploring relief from the good angel who symbolizes the wonderful victories won by Pasteur in combating disease.

Louis Pasteur was born in Dôle, France, in 1822, and died in 1895.

blood of the products of putrefaction is known as **septicæmia**, or commonly, "blood poisoning." This may result from the use of polluted instruments, hands soiled in treating wounds, gunshot injuries, and from many other causes.

426. Warfare between Bacteria and the Living Cells of the Body. Now, it is very evident that the body must be able to defend itself against the myriads of invisible foes which assail its life at every moment. Otherwise we should fall an easy prey to the germs of disease. As a matter of fact, there is unceasing warfare between the bacteria and their toxins and the living cells of the body. The white blood corpuscles appear to be the warrior cells that fight the battle. A poison of another type, called **antitoxin**, is formed in the serum of the blood, which may antagonize the toxins and destroy their poisonous action.[1]

FIG. 198. Spiral Form of Bacteria found in Cholera. Magnified about 1000 diameters.

DISEASES THAT SPREAD AND DISINFECTANTS

427. How Disease may be prevented and restricted. Two of nature's most efficient safeguards in preventing and restricting disease are **pure air** and **pure water**. Cleanliness, proper clothing, wholesome food, and physical exercise all play an important part in keeping the body in sound health.

[1] Within the past few years remarkable progress has been made by tireless scientific workers in their efforts to modify the action of disease-producing bacteria. For instance, the toxins of diphtheria germs are injected into the blood of a horse. In due time the antitoxin of the disease is removed from the serum of the infected blood, and after proper preparation is injected into the blood of a person exposed to or suffering from diphtheria. The effect is to modify decidedly the action of the poisonous germs of this dread disease.

In the preceding chapters we have learned a few of the simplest principles which underlie the maintenance of good health.

We are now to study very briefly other means which are used to prevent and restrict the spread of disease. One of the most common safeguards against the spread of disease is the use of **vaccination** as a protection against smallpox (Sec. 256). That is, persons who are vaccinated are "immune," as it is called, from smallpox, or have it in a milder form.[1]

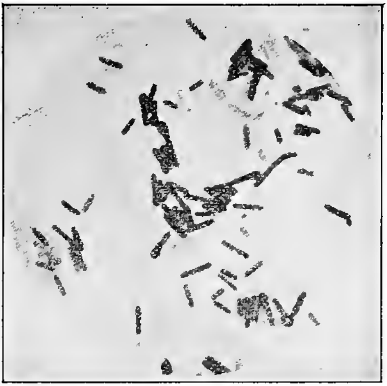

FIG. 199. Rod-Shaped Bacteria, or Bacilli, which cause Lockjaw.

Magnified about 1000 times.

Another very common safeguard against the spread of contagious diseases is **isolation**. The patients, and often the family, are isolated from other people; a rigid system of nursing is instituted; a placard is placed upon the house; the premises are watched; and other familiar means of isolation are employed.

[1] Since the use of animal vaccine has taken the place of the old-time arm-to-arm vaccination, there is little or no danger of inoculating any kind of disease with the vaccine. The use of unclean tools, undue exposure to inclement weather, and neglect or improper treatment of the vaccination wound are often the cause of much unnecessary suffering. As the protective power of vaccination gradually becomes weak with time, it is wise to repeat it every ten years at least. Any one exposed to smallpox ought always to be revaccinated, no matter how recently the operation may have been performed.

428. Disinfection. The destruction of the germs of disease by means of heat, chemical agents, fumigation, or fresh air is known as **disinfection.** It is a most efficient and practical means for preventing the spread of disease.

Some substances kill bacteria and are known as **germicides.** Other substances prevent the development of bacteria and resulting septic action, and these are called **antiseptics.** The word "disinfectant" is often used with more or less confusion to cover both these words.[1]

A **deodorant** is a substance that removes or conceals offensive odors. Deodorizers are not necessarily disinfectants.

429. Some Common Disinfectants. There are many ways of disinfecting, and much interesting research in this direction is going on all the time. The destruction of infected material by **fire** is a sure but costly means of disinfection. **Heat** in various forms, as dry heat, steam, and boiling water, is a valuable disinfectant and does not injure most fabrics. These agents are generally used in combination with various chemical disinfectants.

Certain **chemical agents** that are capable of destroying microörganisms are in general use. A compound of mercury, called **corrosive sublimate,** is a most efficacious and powerful germicide, but is exceedingly poisonous and can be bought only under restrictions.

[1] The sense in which the word "disinfectant" is commonly used is often wrong. When people say they will "disinfect" something, they generally mean that they will use some chemical to destroy a bad smell or mask it by another bad smell. The odor in itself is all the while quite harmless, although disagreeable, and even if it were a terrible menace, the drowning of it in another bad smell would not lessen the danger. As a matter of fact, many of the worst products of decomposition are odorless. When people use the word, therefore, in this sense, they should say "deodorize."

Carbolic acid, chloride of lime, permanganate of potash, sulphur, formaldehyde (formalin gas), and various preparations made from zinc, iron, and petroleum are the disinfectants which are most used at the present time.[1]

There are also numerous varieties of commercial disinfectants now in popular use which the manufacturers declare to be efficient germicides.

430. Hints for the Prevention and Restriction of a Few of the More Common Infectious Diseases. A few hints and helps about the prevention and restriction of some of the more common and dangerous infectious diseases should be understood by every pupil in the elementary grades.[2]

431. Pneumonia. Pneumonia is believed to be spread by a germ which is in the sputum of those who have the disease. Care should always be taken to destroy or disinfect all sputa.

432. Influenza. Influenza, commonly called "grip," is now believed to be spread by a germ which finds its way from infected handkerchiefs and other articles and places into the nose, throat, and air passages of persons susceptible to this disease.

433. Consumption. Consumption is spread by the dust of dried sputa and also by milk and meat of diseased cattle.

[1] Sulphur is an inexpensive, convenient, and satisfactory disinfectant. The infected room is first tightly closed. The cracks about the windows and doors are securely plugged with cotton or rags. The sulphur is put into a metal dish which rests upon bricks in a tub containing an inch or two of water. The sulphur, moistened with a little alcohol, is then ignited. The room is quickly closed and should be kept closed twenty-four hours.

[2] The necessary limitations of an elementary text-book for schools do not allow such a full treatment of the prevention and restriction of infectious diseases and their disinfection as the subject deserves. For more details, consult Conn's *Bacteria, Yeasts, and Molds*, Chapters XVI and XVII, pp. 241–266.

The most important measure for the restriction of **consumption** is the disinfection or destruction of all sputa[1] of every consumptive person and the strict supervision of all animals which furnish food (Sec. 237).

434. Scarlet Fever. Scarlet fever has not yet been identified by its special germ, but that there is a germ seems to be proved by the well-known fact that this disease can be communicated from person to person. It is spread by the discharges from the nose, mouth, and throat, and probably also by the minute scales and bits of dust which are thrown off from the surface of the body.

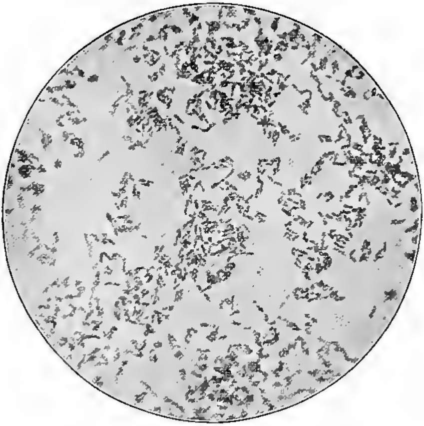

FIG. 200. Bacilli of Diphtheria.
Magnified 1000 diameters.

Isolation and disinfection are the measures by which this disease is restricted.

435. Diphtheria. Diphtheria is spread by the sputa, saliva, and whatever comes from the throat and mouth of the patient, and by the dust which results from the drying of such substances. The germs of diphtheria sometimes remain in the throat weeks after apparent recovery.

[1] All persons suffering from this disease and who have a cough should carry small pieces of cloth (each just large enough to receive one sputum properly) and paraffined paper envelopes or wrappers in which the cloth, as soon as once used, may be securely inclosed and with its envelope burned at the first opportunity. These pieces of cloth must not be carried loose in the pocket and allowed to dry after being used.

For the restriction and prevention of this disease isolation and disinfection are the important measures, — isolation of every infected person and thing, and complete disinfection.

436. Typhoid Fever. Typhoid fever is not so often contracted directly from contact with the sick person as it is from the discharges from the bowels and kidneys. These should always be properly disinfected. Undisinfected discharges, if dried into dust, may spread the disease through the air.

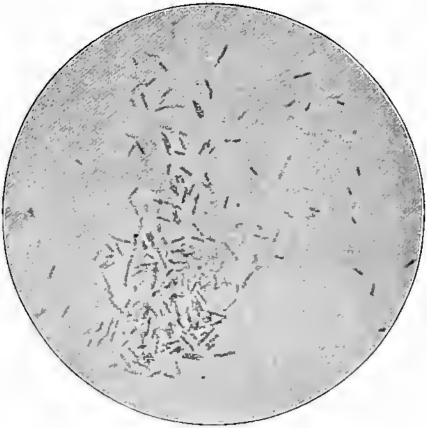

FIG. 201. Bacilli of Typhoid Fever. Magnified 1000 diameters.

The chief source of danger, however, is believed to be drinking water contaminated by sewage or leachings from outbuildings. The germs of typhoid fever are not always killed by freezing, but are destroyed by boiling. All suspected water should be boiled.

THE CARE OF THE SICK ROOM

437. Help in Sickness. Every boy or girl who is over twelve years old should learn a few of the simplest things about taking care of the sick and the sick room. One may be called upon at any moment to lend a hand in nursing the sick. People who are unable to secure the services of

a skilled nurse are often forced for this or other reasons to depend upon one or more of a large family of children to help in the sick room.

Pupils should learn, therefore, at school such things about taking care of the sick as may be easily understood. Such practical knowledge is invaluable, for it may be put to a test at any moment. Aside from the satisfaction in having this knowledge is the opportunity so often afforded to give substantial help to those who need it in times of sickness and suffering.

438. The Proper Location of the Sick Room. The sick room should be the lightest and most pleasant room in the house. Some one of the family may be taken sick in some inconvenient room. If there is a prospect of a long illness, and it is possible, get a room ready at once on a quiet and sunny side of the house.

Take away all extra carpets, upholstered furniture, heavy curtains, etc. A clean floor, with a few rugs to deaden the footsteps, is much better than a woolen carpet. Carpets, extra clothing, etc., only absorb impurities and make the room foul.

439. Need of Fresh Air and Sunlight. The sick room should have plenty of **fresh air** and **sunlight**. It is generally best to shade the room somewhat in certain diseases, but we should let in all the sunlight consistent with comfort. Sunlight and fresh air are often more efficient helps than drugs. They cost nothing but a little painstaking and common sense.

With a little care every sick room may be supplied with pure air. If you cannot do anything else, cover the sick person all over with extra bedclothes, open the windows and doors, and fan out the bad air by swinging the doors.

FIG. 202. A Nurse for the Sick Room.

Be sure to avoid draughts of cold air. Have a thermometer and keep the temperature as the doctor directs.

440. Hints for the Care of the Sick Room. Do not allow a lamp with its flame turned down to burn through the night. A close room with such an odor for a whole night is enough to make a well person sick. If there is no gas or electric light, either use the lamp as usual and put it, carefully shaded, in an adjoining room, or, better still, use a sperm candle for a night light.

Care must be taken to protect the patient from any noise which may disturb him, such as the noise of passing steam and electric cars, heavy teams, and playing children.

Keep a sick room neat and trim. Remove at once all excreta and other offensive matters. Never allow such things to remain even for a short time in the room. In many diseases, especially scarlet fever, diphtheria, and consumption, use pieces of old linen instead of handkerchiefs, and burn them as soon as they are used. Carelessness in this matter often spreads contagious diseases.

441. Additional Hints and Helps. Change the clothes of the bed and of the patient often. Do not let such clothing be put away in a closet with others. Put it to soak at once in boiling water with some disinfectant added if necessary. The fresh sheets and pillow cases should be thoroughly dry and warm and never damp.

Do not make a great show of bottles of medicines, spoons, glasses, etc., carefully spread out on the table. Keep all such things, except those absolutely necessary, in an adjoining room. To a patient not used to sickness, a formidable array of drugs and apparatus is apt to be discouraging. Some simple thing like an orange, a tiny bouquet of favorite flowers, or one or two playthings may take their place.

442. Whispering in the Sick Room. Never get behind the door, in a corner, or in an adjoining room and whisper. It will fret a well person, to say nothing of its hurtful effects upon a sufferer whose nerves may be sensitive to the faintest noise.

Whatever must be said, say it openly and aloud. How often a sudden turn in bed or a quick glance of inquiry shows that whispering is doing harm!

If the patient is in his right mind, answer his questions plainly and truthfully. It may not be best to tell **all** the truth, but nothing is gained by trying to avoid a straightforward reply.

443. Other Suggestions for taking care of Sick People. Do not allow yourself to take a nap while watching. Get a breath of fresh air or take a bit of food or hot drink, if you begin to feel drowsy. A good lunch after midnight and a brief period of rest will greatly relieve the tired and sleepy feeling.

If a physician is employed, carry out his orders to the very letter as long as he visits you. Make a note of his directions on a slip of paper. Make brief memoranda of exactly what you do, such as the precise time of giving medicines, the quantity and kind of nourishment, and an exact record on the temperature chart. This should always be done in serious cases, and especially by night watchers. Then there is no guesswork. All such things are valuable helps to the doctor.

Above all, let there be cool, wise heads, willing hands, loving hearts, and a great deal of common sense on the part of helpers in the sick room.

444. Nursing in Contagious and Infectious Diseases. On the physician rests a great responsibility in the care and

thorough isolation of those who are suffering from the various kinds of infectious and contagious diseases.

Next to the doctor much depends upon the person who has charge of nursing the patient. Those who nurse the sick should see to it that their persons and clothing are kept surgically neat and clean. The trained nurse, for instance, wears a cap to protect her head, for it is known that the hair makes a good lodging place for bacteria.

The face, hair, and hands should be carefully washed with some disinfectant, especially after handling the person, the bedding, or the clothing of the patient. Rigid cleanliness of the finger nails is necessary. Nurses should change the clothing worn in the sick room when they leave the room to mingle with the family or to walk on the street for exercise.

445. Hints on nursing Contagious and Infectious Diseases. Strip the room of superfluous rugs, carpets, and furniture. Isolate two rooms if possible, and have these, if convenient, at the top of the house.

The most scrupulous care should be taken in regard to cleanliness. Old pieces of linen, cheese cloth, and paper napkins should be used whenever convenient or necessary and then burned at once. All soiled clothing that cannot well be burned should be put to soak at once in disinfectants and afterwards boiled apart from the family wash. Dishes and all utensils should be kept scrupulously clean by frequent boiling.

For the bed and person old and worn articles of clothing that can be destroyed should be worn as far as possible. Tack sheets, wet in some proper disinfectant, to the outer frame of the sick-room door. Boil these sheets every third or fourth day (Secs. 430–436).

In case of diseases to which the young are very susceptible, send the children who have not been attacked, if possible, to other houses where there are no children.[1]

[1] There are a few simple rules whose observance will reduce the chances of contagion. These rules should be followed by all, but it is particularly important that children in every household, and especially children in schools, should be taught their significance. The most important rules are:

Do not spit on the floor. Do not wet the fingers in the mouth for the purpose of turning the leaves of books, especially library or school books, inasmuch as book leaves are sometimes the lurking places of disease-producing bacteria.

Books used by children recovering from diphtheria or scarlet fever and then returned to a public library may distribute disease through a community.

Do not put pencils in the mouth. Do not put money in the mouth. This is extremely important, because money is liable to come in contact with all sorts of people and to become contaminated with many kinds of disease-producing bacteria.

Do not put into the mouth anything that another person has had in his mouth. This refers to gum, apple cores, candy, whistles, bean blowers, drinking cups, etc.

In towns where the school officials furnish supplies children should be cautioned against putting into their mouths articles belonging to other children.

Turn the face aside from others when coughing. This will sometimes prevent contagion passing from one person to another, inasmuch as the breath in coughing distributes disease germs.

Always be particular about personal cleanliness, frequently washing the face and hands.

Even a knife or a spoon coming from the sick room should be placed in boiling water before it is used by any other person. Water that is simply hot is not sufficient for this purpose. The water must be *boiling*, and it is better if the articles are placed in the water and the water boiled for five or ten minutes before they are taken out to be used. — Adapted from Conn's *Bacteria, Yeasts, and Molds.*

QUESTIONS ON THE TEXT

1. What change may occur in various kinds of food in hot weather? 2. To what are these changes due? 3. What are some of the names given to these living organisms? 4. What are bacteria? 5. How do bacteria reproduce themselves? 6. State briefly the importance of the work done by bacteria. 7. What can you say about disease-producing bacteria? 8. Describe the action of bacteria upon food. 9. How may bacteria gain access to the body? 10. How may disease be spread by contagion?

11. Give illustrations to show how diseases may be spread by insects. 12. In what two ways may bacteria act in the body? 13. Illustrate the distribution of bacteria by describing how typhoid fever spreads. 14. What is meant by septicæmia, or blood poisoning? 15. How does the body defend itself against bacteria? 16. What are the two great safeguards against the spread of disease? 17. What other means are used to prevent and restrict the spread of disease? 18. What is disinfection? 19. Define germicides, antiseptics, and deodorants. 20. Explain briefly the use of fire and the various forms of heat as disinfectants.

21. What are some chemical agents that are used as disinfectants? 22. What can you say about the spread of pneumonia and influenza? 23. Describe in some detail the means used to restrict the spread of consumption. 24. What can you state about the spread of scarlet fever? 25. How may diphtheria be spread, and what are the two important measures used to restrict the disease? 26. How may typhoid fever be spread? 27. Why should young people learn to take care of the sick? 28. Describe the proper location of the sick room. 29. Explain the need of fresh air and sunlight. 30. Mention some practical points about the care of the sick room.

31. What additional hints concerning the sick room can you give? 32. What are some of the ill effects of whispering in the sick room? 33. What other suggestions about taking care of sick people can you give? 34. What are some precautions necessary to be taken by nurses in infectious and contagious diseases? 35. Give some suggestions about nursing patients suffering from contagious and infectious diseases.

APPENDIX

THE STUDY OF PHYSIOLOGY IN ELEMENTARY SCHOOLS

Within a few years the methods of teaching physiology have changed radically for the better. No progressive teacher of to-day rests content with merely teaching the text. The text-book has come to be regarded only as a convenient helper, a crutch to lean upon, a basis upon which to build good work. Hence every topic in this text-book should be more fully explained, amplified, and illustrated. To secure the best results, a great variety of exercises should be arranged to help fasten the facts in the pupil's memory and to make the study interesting, useful, and practical. The author begs leave in this connection to present in outline a few of the more practical helps which have been utilized and tested in conducting classes in elementary physiology.

1. Preliminary Oral and Written Work. Teachers should give their pupils a pleasant introduction to the work by a familiar talk on the general subject of studying physiology and hygiene. One or two lessons may be devoted to this topic. A carefully prepared outline should be written on the blackboard with catchwords enough to allow the pupil to follow readily. Impromptu questions and answers should be encouraged. The outline should be copied by the pupils into blank books with such catchwords as may make the meaning clear for future reference. The several points should be clinched with many homely and striking bits of information and picturesque illustrations.[1]

[1] A suggestive blackboard outline to cover this point, together with a more detailed discussion of the several topics treated in this Appendix, may be found in the author's little book entitled "How to Teach Physiology," a handbook for teachers. A copy of this pamphlet will be sent postpaid on receipt of ten cents to any address by the publishers of this book.

2. The Use of a Blank Book. Every teacher of physiology will find a blank book of great service. Into this may be copied a great variety of working memoranda, apt quotations, lists of special topics and subtopics, additional practical experiments obtained from other teachers and text-books, examination and test questions, blackboard sketches, etc., gathered from many and varied sources. Everything should be numbered and labeled for quick reference, and cross references should be made to the home text-book.

An extra copy of the school text-book should be kept for home use. Insert blank paper leaves or utilize blank margins of pages. to insert catchwords and cross references to all sorts of illustrative material which may be collected and arranged from sundry notebooks, scrapbooks, and newspaper clippings.

3. The Use of a Scrapbook. A well-kept and indexed scrapbook is also extremely useful to the busy teacher of physiology. Clippings of odd and interesting facts and instructive matter pertaining to physiology and health, which have been culled from newspapers, magazines, and periodicals generally, may conveniently be preserved in this manner. An old geography or a discarded account book will answer every purpose. Cross references should be made to the home text-book and to the blank book.

4. How Teachers may utilize the Blackboard. The blackboard is very helpful in teaching physiology. It should be utilized for health maxims, golden texts, topics for oral and written work, review analyses, tables, and references of various kinds. The teacher can readily learn to make the necessary sketches rapidly and correctly on the blackboard. Sketches which take much time and pains should be made before or after the school session. Offhand sketches should be used every day and should be drawn in the presence of the class to illustrate sundry points in the text.

5. How Pupils may utilize the Blackboard. The pupils themselves should be taught to do a goodly amount of work on the blackboard. Sketches of bones (Fig. 12, p. 19), diagrams of the circulation (Fig. 92, p. 149), tables of bones (p. 42), etc., should be put upon the blackboard by the pupils with as much confidence, neatness, and rapidity as they would use in writing out an exercise in language or in doing an example in arithmetic. Sketches which demand extra time and labor may be drawn before or after the regular session and allowed to remain on the board as long as convenient.

So simple a matter as using red crayon for the arteries, blue for the veins, yellow for the nerves, and white for the bones will add much to the attractiveness of the work. Duplicate copies of all this blackboard work may be used by the pupils to illustrate their own blank books. (See also Figs. 65, p. 103; 77 and 78, pp. 118 and 119; and 105, p. 168.)

6. Books for Collateral Reading and Reference. A certain number of books on physiology and hygiene are useful for collateral reading and quick reference. Their number and character will depend largely upon the grade of the pupil for whom they are intended. Second-hand text-books of the same grade as the class text-book are easily purchased of dealers. Such books may be kept on the teacher's desk for the pupil to consult in school hours or to carry home and read at leisure. Passages in these books which are interwoven with the topics under consideration should be marked with colored pencil by the teacher to aid the pupil in his researches.

7. The Use of Homemade Apparatus. It is scarcely advisable to recommend the use of a manikin, separate bones, a skeleton, and physiological charts for use in the elementary grades. As a matter of fact, very few school officials can afford to furnish their school-rooms with such useful but costly material. Fortunately, however, most teachers can copy passably well illustrations taken from other books. With a little painstaking and ingenuity the teacher of even the more remote district schools can make a few charts which will prove effective helps toward making the work successful. For this purpose, white cardboard or even manila paper may be used upon which to make the sketches in colored inks or crayons. For apparatus with which to hang or construct charts, eyelets, curtain fixtures, stout cords, clothespins, telephone wire, pasteboard boxes, colored paper, and many other things have been used.

For the encouragement of teachers in remote sections it may be well to mention the fact that many eminent scientists do not hesitate to make very crude drawings on the blackboard, and often resort to the use of their own hats, umbrellas, canes, handkerchiefs, pocket-knives, and other articles to illustrate their lectures.

It is, perhaps, unnecessary to state that the collection and preparation of the working material which has been suggested may demand much labor and patience for the first year, but that it can be kept for use in succeeding classes.

8. Importance of Experiments in teaching Physiology in Elementary Schools. The subject-matter as set forth in the preceding chapters of this book should be carefully studied and read. At the same time, however, the topics studied should be amplified and made more interesting and practical by a series of experiments given in connection with the several chapters, a goodly show of specimens, and a certain amount of microscopical work.

The experimental method of teaching the sciences rivets the attention and arouses and keeps alive the interest of the young student; in fact, it is the only true method of cultivating a scientific habit of study. Every teacher knows that pupils gain a far better knowledge and keep up a livelier interest in their work, if they are able to see with their own eyes and to do with their own hands that which serves to illustrate the particular branch of science in which they are engaged.[1]

9. The Use of Inexpensive Apparatus. It will be noted that most of the experiments which have been suggested in the preceding chapters of this book can be performed with very simple and often crude homemade apparatus. This plan has been followed by the author: first, because he fully realizes the limitations of the subject; and secondly, because he wishes to emphasize the fact that expensive and complicated apparatus is by no means necessary to illustrate the great principles of anatomy and physiology.

In schools in which both the funds and the time for experimental work are limited, the zeal and ingenuity of teachers and students are often put to a severe test. Fortunately, a very little money and a great deal of ingenuity and patience will do much towards providing a working supply of apparatus.

10. The Microscope in Elementary Schools. For elementary class work a moderate-priced but well-made and strong microscope should be provided. If the school does not own or cannot afford to buy a microscope, the loan of an instrument should be obtained for at least a few weeks from some person in the neighborhood.[2]

[1] A number of books, prepared for the use of teachers and students who wish to supplement the text-book with experimental work, have been recently published. Of these books the teacher is advised to use James E. Peabody's *Laboratory Exercises in Anatomy and Physiology* (Henry Holt & Co., New York, publishers; price 60 cents); and Bertha M. Brown's *Physiology for the Laboratory* (Ginn & Company, publishers; price 75 cents).

[2] The catalogues of scientific-instrument makers usually furnish a list of the requisite materials for experimental use or the titles of handbooks which describe

The appearance of the various structures and tissues of the human body as revealed by the microscope possesses a curious fascination for every observer, especially for young students. No one ever forgets the first look at a drop of blood, or the circulation of blood in the web of a frog's foot as revealed by the microscope.

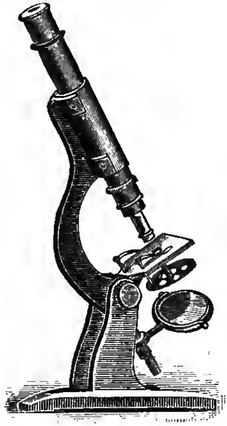

FIG. 203. A Compound Microscope.

11. **Dissection in Elementary Schools.** A few simple dissections which can be made with fresh beef joints and legs of chickens and turkeys will answer every purpose in the elementary grades. A discreet teacher should rarely advise his pupils to dissect a dead cat, dog, frog, or any other animal. Instead of actually dissecting, the pupils should examine specimens or certain parts previously dissected by the teacher, — as the muscles and joints of a sheep, the heart of an ox, the eye of a codfish, and so on.

12. **Teaching Surface Anatomy and Landmarks of the Body.** In elementary work it is only fair to state that comparatively few points concerning the surface anatomy and landmarks of the body can be defined or located with precision. A certain amount of work in this direction can, however, be done, even in elementary schools, with ingenuity, patience, and a due regard for the feelings of all concerned. For example, the student may be taught to examine the muscles and other parts of his own face, his teeth, tongue, and palate, and the bones and muscles of his shoulders and limbs. Two friends may thus work together, each serving as a model to the other.[1]

the use of the various microscopes of standard make. For detailed suggestions in regard to the manipulation and use of the microscope the student is referred to any of the standard works on the subject.

For the names and addresses of firms that deal in microscopes and apparatus for experiments consult the advertising pages of leading educational publications.

[1] On pages 415–419 in the author's *Practical Physiology* may be found a syllabus of a brief course of study concerning surface anatomy and landmarks of the body.

GLOSSARY OF TECHNICAL TERMS

Many words that are defined or explained as they occur in the text of this book, or the meaning of which is readily understood, have been omitted in this Glossary.

Ab-do′men (Lat.). The largest cavity of the body, containing the liver, the stomach, the intestines, and other organs.

Ab-sorb′ent (Lat. *absorbere*, to suck up). An organ or part that absorbs; a lymphatic vessel.

Ab-sorp′tion. The process of sucking up nutritive or waste matters by the blood vessels or lymphatics.

Ac-com′mo-da′tion of the eye. The alteration in the shape of the crystalline lens which adjusts the eye for near vision.

Ac-e-tab′u-lum (Lat. *acetabulum*, a vinegar cup). The cup-shaped cavity of the innominate bone which receives the head of the femur.

A-cro′mi-on (Gr. ἄκρος, extreme, and ὦμος, the shoulder). The part of the scapula forming the tip of the shoulder.

Al-bu′men (Lat. *albumen*, white of egg). Formerly used as a synonym for proteid.

Al-bu′min (*albumen* and *-in*). A class of proteids, as egg albumin.

Al′i-men′ta-ry (Lat. *alere*, to nourish). Pertaining to aliment, or food.

Al′i-men′ta-ry ca-nal′. The digestive tube from the lips to the end of the rectum, with its accessory glands.

Al′ka-lies (Arabic *al*, the, and *qalīy*, ashes of saltwort). Certain substances, such as soda, potash, and the like, which unite with acids to form salts.

A-mœ′ba (Gr. ἀμοιβή, a change). A single-celled, protoplasmic animal, which has the power of changing its form by protrusions and withdrawals of its substance.

A-mœ′boid. Like an amœba in form or in movement.

An′æs-thet′ic (Gr. ἀν-, not, and αἰσθητός, perceptible). A substance which produces insensibility to pain or to touch, as chloroform, ether, etc.

An′ti-dote (Gr. ἀντί, against, and δοτός, given). A substance given to prevent or counteract the action of a poison.

An′ti-sep′tic (Gr. ἀντί, against, and σήπειν, to make rotten). A remedy

or agent which prevents the development of bacteria, or prevents the growth of bacteria upon which putrefaction depends.

An′ti-tox′in (Gr. ἀντί, against, and *toxin*). A substance which neutralizes the action of the toxins of bacteria. Antitoxins are used in the treatment of certain infectious diseases, as diphtheria.

An′trum (Gr. ἄντρον, a cave). The cavity in the upper jaw.

Ap′pa-ra′tus. Used to designate collectively organs which perform a certain function.

Ap-pen′di-ci′tis (Lat. *appendix*). Inflammation of the appendix vermiformis of the cæcum.

A′que-ous hu′mor (Lat. *aqua*, water). The watery fluid occupying the space between the cornea and the crystalline lens of the eye.

Ar′bor vi′tæ (Lat. *arbor vitae*, tree of life). A name given to the treelike appearance of a section of the cerebellum.

A-re′o-lar tis′sue (Lat. *areola*, dim. of *area*, a piece of open ground). Connective tissue containing small spaces.

Ar-tic′u-la′tion (Lat. *articulus*, a joint). The more or less movable union of bones, etc.; a joint.

A-ryt′e-noid car′ti-lag-es (Gr. ἀρύταινα, a ladle). Two small cartilages of the larynx, resembling the mouth of a pitcher.

As-phyx′i-a (Gr. ἀ-, without, and σφύζειν, to pulsate). Suffocation. The suspension of vital phenomena when the lungs are deprived of oxygen.

As-sim′i-la′tion (Lat. *ad*, to, and *similis*, like). The conversion of food into living tissue.

Az′y-gos (Gr. ἀ-, without, and ζυγόν, a yoke). Applied to parts that are single, not in pairs.

Ba-cil′lus (Lat. dim. of *baculum*, a staff). A microscopic rod-shaped form of bacteria.

Bac-te′ri-um, pl. **bac-te′ri-a** (Gr. βακτήριον, a little staff). A microscopic vegetable organism.

Bac-te′ri-cide (*bacterium* and Lat. *caedere*, to kill). An agent that destroys bacteria.

Blad′der (Saxon *blædre*, a blister, a bladder). A bag, or sac, serving as a receptacle of some secreted fluid, as the gall bladder, urinary bladder, etc.

Bright's dis-ease′. Disease of the kidneys, first described by Dr. Bright, an English physician.

Cap′il-la-ry (Lat. *capillus*, hair). A minute vessel, as those that connect by a network the arteries and veins.

Cap′sule (Lat. *capsula*, a little chest). A receptacle, or bag.

Car′bon di-ox′ide. A gas produced in the respiration of animals, and in the decay or combustion of organic matter. Often called carbonic acid gas.

Car′di-ac or′i-fice (Gr. καρδία, the heart). The orifice of the stomach, near the heart.

Car′ron oil (from its use at the Carron Iron Works). A mixture of equal parts of linseed oil and limewater.

Car′ti-lage. Gristle. A tough but flexible tissue forming a part of the joints, air passages, nose, ears, etc.

Car′un-cle (lach′ry-mal) (Lat. *caruncula*, dim. of *caro*, flesh). The small, red, conical-shaped swelling at the inner angle of the eye.

Ca′se-in (Lat. *caseus*, cheese). A proteid substance found especially in milk. The principal ingredient in cheese.

Cell (Lat. *cella*, a room). One of the ultimate units of which all living bodies are composed. A granular mass of protoplasm containing a nucleus.

Cer′e-bel′lum (Lat. dim. of *cerebrum*). The part of the brain lying below the cerebrum and above the pons and the medulla oblongata.

Cer′e-brum (Lat.). The brain proper, occupying the upper portion of the skull.

Chi-rop′o-dist (Gr. χείρ, a hand, and πούς, a foot). A person who treats diseases of the hands and feet.

Chlo′ral. A powerful drug and narcotic poison used to produce sleep.

Chlo′ro-form. A narcotic poison generally used by inhalation; of extensive use in surgical operations to produce anæsthesia.

Chor′dæ ten-di′ne-æ (Lat.). Tendinous cords, connecting the papillary muscles of the heart with the auriculo-ventricular valves.

Cho′roid (Gr. χόριον, membrane, chorion, and εἶδος, form). The middle coat of the eyeball.

Cil′i-a (Lat. pl. of *cilium*, an eyelash). Minute threadlike processes found upon the cells of the air passages and other parts.

Cil′ia-ry mus′cle. A small muscle of the eye which assists in accommodation.

Co-ag′u-la′tion (Lat. *coagulare*, to curdle). The process by which a liquid like blood or milk clots, or solidifies.

Co′ca-ine. A bitter, white substance obtained from the leaves of coca, capable of producing local insensibility to pain when applied to the surface of mucous membranes or injected under the skin.

Coch′le-a (Lat. *cochlea*, a snail). The spiral cavity of the internal ear.

Co′ma (Gr. κῶμα, lethargy). A deep stupor from which it is difficult or impossible to arouse a person.

Com′mis-sure (Lat. *com-*, together, and *mittere*, to send). A bridge-like structure uniting similar parts.

Com′press. A pad or bandage applied directly to an injury.

Con′cha (Gr. κόγχη, a mussel). The shell-shaped portion of the external ear.

Con-ges′tion (Lat. *com-*, together, and *gerere*, to bring). Abnormal collection of blood in a part or organ.

Con'junc-ti'va (Lat. *com-*, together, and *jungere*, to join). A thin layer of mucous membrane which lines the eyelids and covers the front of the eyeball, thus joining the latter to the lids.

Con-ta'gion (Lat. *com-*, together, and *tangere*, to touch). The process by which a specific disease is communicated from one person to another, either by contact or by means of an intermediate agent. Also the specific germ, or virus, which causes a communicable disease.

Con'trac-til'i-ty (Lat. *com-*, together, and *trahere*, to draw). The property of a muscle which enables it to draw its extremities closer together.

Con'vo-lu'tions (Lat. *com-*, together, and *volvere*, to roll). Tortuous foldings, as those of the external surface of the brain.

Co-ör'di-na'tion. The manner in which different organs of the body are made to work together.

Cor'ne-a (Lat. *cornu*, a horn). The transparent hornlike substance which covers a part of the front of the eyeball.

Cor'pus-cle (Lat. *corpusculum*, dim. of *corpus*, a body). A small body or particle.

Cri'coid (Gr. κρίκος, a ring, and εἶδος, form). A cartilage of the larynx resembling a seal ring in shape.

Crys'tal-line lens (Gr. κρύσταλλος, ice, crystal). One of the refractive media of the eye; a double-convex body situated in the front part of the eyeball.

Cu'ti-cle (Lat. *cuticula*, dim. of *cutis*). Scarfskin; the epidermis.

Cu'tis (Lat. *cutis*, the skin). The true skin, also called the dermis.

De-gen'er-a'tion (Lat. *de*, from, down, and *genus*, race). A morbid process in the structure of an organ by which its tissues are converted into some inert substance.

Deg'lu-ti'tion (Lat. *deglutire*, to swallow). The act of swallowing.

Den'tine (Lat. *dens*, a tooth). The hard substance which forms the greater part of the tooth; ivory.

De-o'dor-ant (Lat. *de*, without, and *odorare*, to smell). A substance which removes or conceals offensive odors.

Dex'trin (Lat. *dexter*, right). A soluble carbohydrate into which starch is converted by diastase or dilute acids or by dry heat.

Dex'trose' (Lat. *dexter*, right). Grape sugar.

Dis'in-fect'ants. Agents used to destroy the germs of disease, fermentation, and putrefaction.

Dis'lo-ca'tion (Lat. *dis-*, contrary to, and *locare*, to place). An injury to a joint in which the bones are displaced or forced out of their sockets.

Dis-sec'tion (Lat. *dis-*, apart, and *secare*, to cut). The cutting up of an animal to learn its structure.

Du'o-de'num (Lat. *duodeni*, twelve each). The first division of the

small intestines, about twelve fingers' breadth long.

Dys-pep′si-a (Gr. *δύσ-*, difficult, and *πέπτειν*, to digest). The name given to certain diseases of the digestive organs.

Ef-flu′vi-a (Lat. *effluere*, to flow out). Offensive odors coming from the body, and from decaying animal or vegetable substances.

El′e-ment One of the simplest parts of which anything consists.

E-lim′i-na′tion (Lat. *e*, out, and *limen*, a threshold). The act of expelling waste matters. Signifies literally "to throw out of doors."

E-met′ic (Gr. *ἐμετικός*, causing vomiting). An agent which causes vomiting.

E-mul′sion (originally milky juice from almonds bruised in water; from Lat. *emulgere*, to milk out). A preparation consisting of a liquid, usually water, containing an insoluble substance, as fat, in suspension.

E-nam′el (Fr. *en*, in, and *émail*, enamel). Dense material covering the crown of a tooth.

Ep′i-dem′ic (Gr. *ἐπί*, upon, and *δῆμος*, the people). A disease which affects large numbers, or which spreads over a wide area.

Ep′i-glot′tis (Gr. *ἐπί*, upon, and *γλωττίς*, the entrance to the windpipe). A leaf-shaped lid which covers the top of the larynx during the act of swallowing.

Ep′i-lep′sy (Gr. *ἐπί*, upon, and *λαβεῖν*, seize). A nervous affection accompanied by fits and sudden loss of consciousness.

E′ther (Gr. *αἰθήρ*, the pure upper air). A narcotic poison. Its chief use is as an anæsthetic in surgical operations.

Eu-sta′chi-an tube (from an Italian anatomist named Eustachio). The tube which leads from the throat to the middle ear.

Ex-cre′ta (Lat. *excernere*, to separate). The refuse matter which is passed from the body in any form.

Ex-cre′tion (Lat. *excernere*, to separate). The separation from the blood of the waste matters of the body; also the materials excreted.

Fas′ci-a (Lat. *fascia*, a band). The areolar tissue forming layers beneath the skin or between muscles.

Fau′ces (Lat.). The part of the mouth which opens into the pharynx.

Fe-nes′tra o-va′lis and **fenestra ro-tun′da** (Lat. *fenestra*, a window). The oval and the round window; two apertures in the bone between the tympanic cavity and the labyrinth of the ear.

Fer′ment (Lat. *fermentum*, leaven). Any substance which in contact with another substance is capable of setting up changes (fermentation) in the latter, without itself undergoing much change.

Fer′men-ta′tion (Lat. *fermentum*, leaven). An effervescent change, as by the action of yeast; in a wider sense, the change of organic substances into new compounds by the action of a ferment. It differs in kind according to the nature of the ferment.

Fi-bril′la (Lat. dim. of *fibra*, a fiber). A little fiber; one of the longitudinal threads into which a striped muscular fiber can be divided.

Fi′brin (Lat. *fibra*, a fiber). A proteid substance contained in the flesh of animals, and also produced by the coagulation of blood.

Fol′li-cle (Lat. *folliculus*, dim. of *follis*, a bag). A little pouch or depression, as the hair follicle.

Fo′men-ta′tion (Lat. *fomentum*, a warm lotion or poultice). The application of heat and moisture to a part to relieve pain and reduce inflammation.

Fo-ra′men (Lat. *forare*, to pierce). A hole, or an aperture.

Fron′tal si′nus (Lat. *frons*, the forehead). A blind or closed cavity in the bones of the skull just over the eyebrows.

Fu′mi-ga′tion (Lat. *fumigare*, to smoke). Disinfection by means of a vapor.

Func′tion (Lat. *fungi*, to perform). The normal or special action of a part.

Gan′gli-on (Gr. γάγγλιον, a tumor on or near a tendon). A collection of nerve cells.

Gel′a-tin (Lat. *gelare*, to congeal). An albuminoid substance which dissolves in hot water and forms a jelly on cooling.

Germ (Lat. *germen*, a sprout, bud). A portion of matter capable of developing into a living organism, — a microörganism.

Ger′mi-cide (*germ* and Lat. *caedere*, to kill). An agent which destroys germs, especially bacteria.

Gland (Lat. *glans*, an acorn). An organ consisting of one or more follicles and ducts, with numerous blood vessels interwoven.

Glot′tis (Gr. γλῶττα, the tongue). The space between the vocal cords.

Glu′cose′ (Gr. γλυκύς, sweet). A kind of sugar found in fruits, also known as grape sugar.

Gly′co-gen (Gr. γλυκύς, sweet, and -γενής, producing). A substance belonging to the carbohydrates, found especially in the liver; also known as animal starch.

Hem′i-sphere (Gr. ἡμι-, half, and σφαῖρα, a sphere). Half a sphere; the lateral halves of the cerebrum.

Hem′or-rhage (Gr. αἷμα, blood, and ῥηγνύναι, to burst). Bleeding, or the loss of blood.

He-pat′ic (Gr. ἧπαρ, the liver). Pertaining to the liver.

He-red′i-ty (Lat. *hereditas*, heirship). The predisposition or tendency derived from one's ancestors to definite physiological actions or anatomical peculiarities.

Hu′mor (Lat. *humor*, moisture). The transparent contents of the eyeball.

Hy′a-line (Gr. ὕαλος, glass). Glass-like, resembling glass in transparency.

Hy′dro-gen. An elementary gaseous substance, which, in combination with oxygen, produces water.

Hy′dro-pho′bi-a (Gr. ὕδωρ, water, and φόβος, fear). A disease caused by the bite of a rabid dog or other animal.

Im-mune′ (Lat. *immunis*, exempt). Exempt from certain diseases by inoculation, by previous attack, or by nature.

In-ci′sor (Lat. *incidere*, to cut into). Applied to the four front teeth of both jaws, which have sharp, cutting edges.

In′cus (Lat. *incus*, an anvil). One of the bones of the middle ear.

In′di-an hemp. The common name of *Cannabis indica*, an intoxicating drug known as "hasheesh" and by other names in Eastern countries.

In-fec′tion (Lat. *inficere*, to stain). The communication of disease from one body to another, or from one part to another part of the same individual (auto-infection). The material conveying the disease; the disease-producing agent.

In-fe′ri-or ve′na ca′va (Lat.). The vein carrying blood from the lower part of the body into the heart.

In′flam-ma′tion (Lat. *in*, in, and *flamma*, a flame). Tissue changes accompanied with redness or swelling of any part of the body, with heat and pain.

In-oc′u-la′tion (Lat. *inoculare*, to ingraft). The introduction of the germs of disease, generally through the skin, so as to produce the disease.

I′ris (Gr. ἶρις, the rainbow). The thin muscular ring which lies between the cornea and crystalline lens, giving the eye its special color.

Jaun′dice (Fr. *jaune*, yellow). A disorder in which the skin, eyes, mucous membranes, and secretions assume a yellowish tint, due to the presence of bile pigments in the blood.

Lab′y-rinth (Gr. λαβύρινθος, a maze). The internal ear, so named from its many windings.

Lach′ry-mal ap′pa-ra′tus (Lat. *lacrima*, a tear). The organs for forming and carrying away the tears.

Lens (Lat. *lens*, a lentil). A piece of transparent glass or other substance so shaped as either to converge or disperse the rays of light.

Lig′a-ture (Lat. *ligare*, to bind). A thread of some material used in tying arteries or other parts.

Lobe (Gr. λοβός, lobe of the ear or liver). A round, projecting part of an organ, as of the liver, lungs, or brain.

Lockjaw, see "Tetanus."

Lymph (Lat. *lympha*, pure water) The watery fluid in the lymphatic vessels.

Mal′le-us (Lat. *malleus*, a hammer). The mallet; one of the small bones of the middle ear.

Me-a′tus (Lat. *meare*, to pass). A natural passage or canal.

Me-dul′la ob-lon-ga′ta (Lat.). The "oblong marrow," also called the spinal bulb; that portion of the brain which lies upon the basilar process of the occipital bone.

Mei-bo′mi-an. A term applied to the small glands between the conjunctiva and tarsal cartilages, discovered by Meibomius.

Mem-bra′na tym′pa-ni (Lat.). Literally, "the drum membrane"; the membrane separating the outer from the middle ear.

Mes′en-ter-y (Gr. *μέσος*, middle, and *ἔντερον*, the intestine). A fold of the peritoneum, surrounding an intestine, especially the small intestine.

Mi′crobe (Gr. *μικρός*, little, and *βίος*, life). A living organism of very small size, — a microörganism, — either animal or vegetable.

Mol′e-cule (Lat. *molecula*, dim. of *moles*, a mass). The smallest portion of a substance which can retain the properties of the substance.

Mo′tor (Lat. *movere*, to move). The name of the nerves which conduct to the muscles the stimulus which causes them to contract.

Mu′cous mem′brane. The thin layer of tissue which covers those internal cavities or passages which communicate with the external air.

Mu′cus (Lat.). The thin glairy fluid secreted by mucous membranes.

Nar-cot′ic (Gr. *ναρκοῦν*, to benumb). A substance that produces stupor, convulsions, and sometimes death.

Nic′o-tine (from Jean Nicot, who introduced tobacco into France). A poisonous substance found in the leaves of the tobacco plant.

Nu-cle′o-lus (Lat. dim. of *nucleus*). A small body often found within the nucleus of a cell.

Nu′cle-us (Lat. *nucleus*, kernel). An essential part of a typical cell, often spherical and usually found near the center.

Œ-soph′a-gus (Gr. *φέρειν*, *οἴσειν*, to carry, and *φαγεῖν*, to eat). The tube leading from the throat to the stomach; the gullet.

Ox-i-da′tion. The union of oxygen with other substances, as in combustion. The essential part of burning and of breathing.

Pal′ate (Lat. *palatum*, the palate). The roof of the mouth, forming the hard palate, and the curtain at the back of the mouth, called the soft palate.

Pal′pi-ta′tion (Lat. *palpitare*, to throb). A violent and irregular beating of the heart.

Pa-pil′læ (Lat. *papilla*, a nipple). The small elevations found on the skin and mucous membranes.

Pa-ral′y-sis (Gr. παρά, beside, and λύειν, to loosen). Loss of function, especially of motion or feeling.

Par′a-site (Gr. παρά, beside, and σῖτος, food). A plant or animal living upon or within another organism, called the host.

Pel′vis (Lat. *pelvis*, a basin). The bony cavity at the lower part of the trunk.

Pep′sin (Gr. πέψις, digestion). A ferment found in the gastric juice, and capable of digesting proteids in the presence of an acid.

Pep′tone (Gr. πέπτειν, to digest). A proteid body formed by the action of ferments on albumins or other proteids during gastric and pancreatic digestion.

Per′i-car′di-um (Gr. περί, about, and καρδία, heart). The sac inclosing the heart.

Per′i-os′te-um (Gr. περί, around, and ὀστέον, a bone). A delicate membrane, which invests and nourishes the bones.

Per′i-to-ne′um (Gr. περιτείνειν, to stretch around). The investing membrane of the stomach, intestines, and other abdominal organs.

Pha-lan′ges (Gr. φάλαγξ, a body of soldiers closely arranged in ranks and files). The bones of the fingers and toes.

Phar′ynx (Gr. φάρυγξ, the throat). The cavity behind the mouth and the nose, leading to the gullet.

Pi′a ma′ter (Lat. *pia mater*, gentle mother). The innermost of the three coverings of the brain. It is thin and delicate; hence the name.

Pin′na (Lat. *pinna*, a wing). The external cartilaginous flap of the ear.

Plas′ma (Gr. πλάσσειν, to mold). The fluid part of the blood and the lymph.

Pleu′ra (Gr. πλευρά, a rib, the side). A membrane covering the lung and lining the chest.

Plex′us (Lat. *plectere*, to braid). A network of vessels, nerves, or fibers.

Pneu′mo-gas′tric (Gr. πνεύμων, the lungs, and γαστήρ, the stomach). The longest of the cranial nerves giving off branches to the lungs, the heart, the alimentary canal, and other parts; also called the *vagus*, or wandering nerve.

Poi′son (Lat. *potio*, a draught). A substance that, when introduced into the body, either destroys life or impairs seriously the function of one or more of its organs.

Por′tal vein (Lat. *porta*, a gate). The venous trunk formed by the veins coming from the stomach and the intestines. It carries the blood to the liver.

Proc′ess (Lat. *pro*, forth, and *cedere*, to go). Any projection from a surface; also, a method of performance, a procedure.

Pro′te-ids (Gr. πρῶτος, first). A general term for the albuminous constituents of the body.

Pro'to-plasm (Gr. πρῶτος, first, and πλάσσειν, to mold). The viscid material constituting the essential substance of living cells upon which all the vital functions of the body depend.

Pto'ma-ine (Gr. πτῶμα, a corpse). One of a class of substances, resembling the vegetable alkaloids, formed during the decomposition of proteids. See "Toxin."

Pty'a-lin (Gr. πτύαλον, saliva). A ferment in saliva, having power to convert starch into sugar.

Pu'pil (Lat. *pupilla*). The central, round opening in the iris, through which light passes into the interior of the eye.

Pus (Lat.). A yellowish-white, creamy liquid produced by suppuration. It consists mostly of cells floating in a liquid.

Py-æ'mi-a (Gr. πύον, pus, and αἷμα, blood). A form of blood poisoning produced by the absorption into the blood of morbid matters usually originating in a wound or local inflammation.

Py-lo'rus (Gr. πυλωρός, a gate keeper). The opening of the stomach at the beginning of the small intestine.

Re'flex (Lat. *reflectere*, to bend back). Involuntary movements or secretion produced by an excitation traveling along a sensory nerve to a center, where it is turned back or reflected along motor or secretory nerves.

Res'pi-ra'tion (Lat. *re-*, again, and *spirare*, to breathe). The act of breathing in and breathing out air.

Ret'i-na (Lat. *rete*, a net). The innermost of the three tunics, or coats, of the eyeball, being an expansion of the optic nerve.

Ri'ma glot'ti-dis (Lat. *rima*, a chink or cleft). The opening of the glottis.

Roent'gen rays. See "X-rays."

Sar'co-lem'ma (Gr. σάρξ, flesh, and λέμμα, a husk). The membrane which surrounds the contractile substance of a striped muscular fiber.

Scle-rot'ic (Gr. σκληροῦν, to harden). The tough, fibrous outer coat of the eyeball.

Se-ba'ceous (Lat. *sebum*, tallow). Resembling fat; the name of the oily secretion by which the skin is kept flexible and soft.

Se-cre'tion (Lat. *secernere*, to separate). The process of separating from the blood some essential, important fluid, which fluid is also called a secretion.

Sem'i-cir'cu-lar ca-nals'. Three canals in the internal ear.

Sep'ti-cæ'mi-a (Gr. σηπτικός, putrefying, and αἷμα, blood). Blood poisoning; a form of poisoning resulting from the presence in the blood of the products of putrefactive microörganisms.

Se'rum (Lat. *serum*, whey). The clear, watery fluid which separates from the clot of the blood.

Spu′tum, pl. **sputa** (Lat. *spuere*, to spit). Matter which is coughed up from the air passages.

Sta′pes (Lat. *stapes*, a stirrup). One of the small bones of the middle ear.

Ster′il-i-za′tion (Lat. *sterilis*, barren). The destruction of micro-organisms, especially by heat. Commonly applied to the preparation of milk for infants, and to surgical dressings.

Stim′u-lant (Lat. *stimulare*, to goad). An agent which causes an increase of activity in the body or in any of its parts without increasing its supply of energy.

Styp′tics (Gr. *στυπτικός*, astringent). Substances that applied locally arrest bleeding.

Sub-cla′vi-an vein (Lat. *sub*, under, and *clavis*, a key). A great vein, so called because it is situated underneath the clavicle, or collar bone.

Su-pe′ri-or ve′na ca′va (Lat.). The great vein of the upper part of the body.

Syn-o′vi-a (Gr. *σύν*, with, and Lat. *ovum*, an egg; a word coined by Paracelsus). The fluid secreted by the synovial membranes, which lubricates the joints; joint oil. It resembles the white of a raw egg.

Tem′po-ral (Lat. *tempora*, the temples). Pertaining to the temples.

Tet′a-nus (Gr. *τείνειν*, to stretch). A disease marked by persistent contractions of all or some of the voluntary muscles; those of the jaw are sometimes solely affected; it is then termed lockjaw.

Thy′roid (Gr. *θυρεός*, a shield, and *εἶδος*, form). The largest of the cartilages of the larynx; its projection in front is called "Adam's apple."

Tis′sue (Fr. *tissu*, from Lat. *texere*, to weave). Any substance or texture in the body formed of various elements, such as cells, fibers, blood vessels, etc., interwoven with each other.

To-bac′co (Indian *tabaco*, the tube, or pipe, in which the Indians smoked the plant). A narcotic plant used for smoking and chewing, and in snuff.

Tox′in (Gr. *τοξικόν*, poison). A poison formed by bacteria in both living tissues and dead substances; a poisonous ptomaine.

Tra′gus (Gr. *τράγος*, a goat). The eminence in front of the opening of the ear; sometimes hairy, like a goat's beard.

Tryp′sin (Gr. *τρίψις*, a rubbing). The ferment principle in pancreatic juice which converts proteid material into peptones.

Tu′ber-cle (Lat. *tuberculum*, dim. of *tuber*, a hump). A pimple, swelling, or tumor; the specific lesion produced by the tubercle bacillus.

Tu-ber′cu-lo′sis (same derivation as "tubercle"). An infectious disease due to the bacillus tuberculosis. The form of this disease with marked pulmonary symptoms

is popularly known as *consumption.*

Tur′bi-na′ted (Lat. *turbo*, a top). Formed like a top; a name given to the bones in the outer walls of the nasal fossæ.

Tym′pa-num (Gr. *τύμπανον*, a drum). The cavity of the middle ear, resembling a drum in being closed by two membranes.

U′re-a (Gr. *οὖρον*, urine). Chief solid constituent of urine; nitrogenous product of tissue decomposition.

U-re′ter (Gr.). The tube through which the urine is conveyed from the kidneys to the bladder.

U′vu-la (Lat. dim. of *uva*, a grape, a bunch of grapes). The small pendulous body at the middle of the soft palate.

Vac′cine vi′rus (Lat. *vacca*, a cow). The virus used in performing vaccination; now usually derived directly from the cow.

Var′i-cose (Lat. *varix*, a dilated vein). Distended or enlarged, as a vein.

Vas′cu-lar (Lat. *vasculum*, dim. of *vas*, a vessel). Pertaining to or possessing blood or lymph vessels.

Ve′næ ca′væ (Lat. pl. of *vena cava*, hollow vein). A name given to the two great veins which meet at the right auricle of the heart.

Ven′ti-la′tion (Lat. *ventilare*, to fan). The process of replacing the foul or vitiated air in any room or confined space with air that is pure.

Ver′mi-form (Lat. *vermis*, a worm, and *forma*, form). Worm-shaped.

Ves′ti-bule (Lat. *vestibulum*, a fore-court). A portion of the internal ear, communicating with the semicircular canals and the cochlea.

Vil′li (Lat. *villus*, shaggy hair). Minute threadlike projections upon the internal surface of the small intestine.

Vi′rus (Lat. *virus*, poison). The poison of an infectious disease, especially one found in the secretions or tissues of an individual or animal suffering from an infectious disease.

Vit′re-ous (Lat. *vitrum*, glass). Having the appearance of glass; applied to the humor occupying the largest part of the cavity of the eyeball.

Viv′i-sec′tion (Lat. *vivus*, alive, and *secare*, to cut). Dissection of a living animal; experimentation upon an animal while still alive.

Vo′cal cords. Two elastic bands or transverse folds of the larynx.

X-rays, or **Roent′gen rays.** The peculiar ether rays or waves discovered by Roentgen in 1895. These rays penetrate substances like wood, the bodily tissues, and many other substances which are opaque to the light of the sun; extensively used in the diagnosis of surgical cases.

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